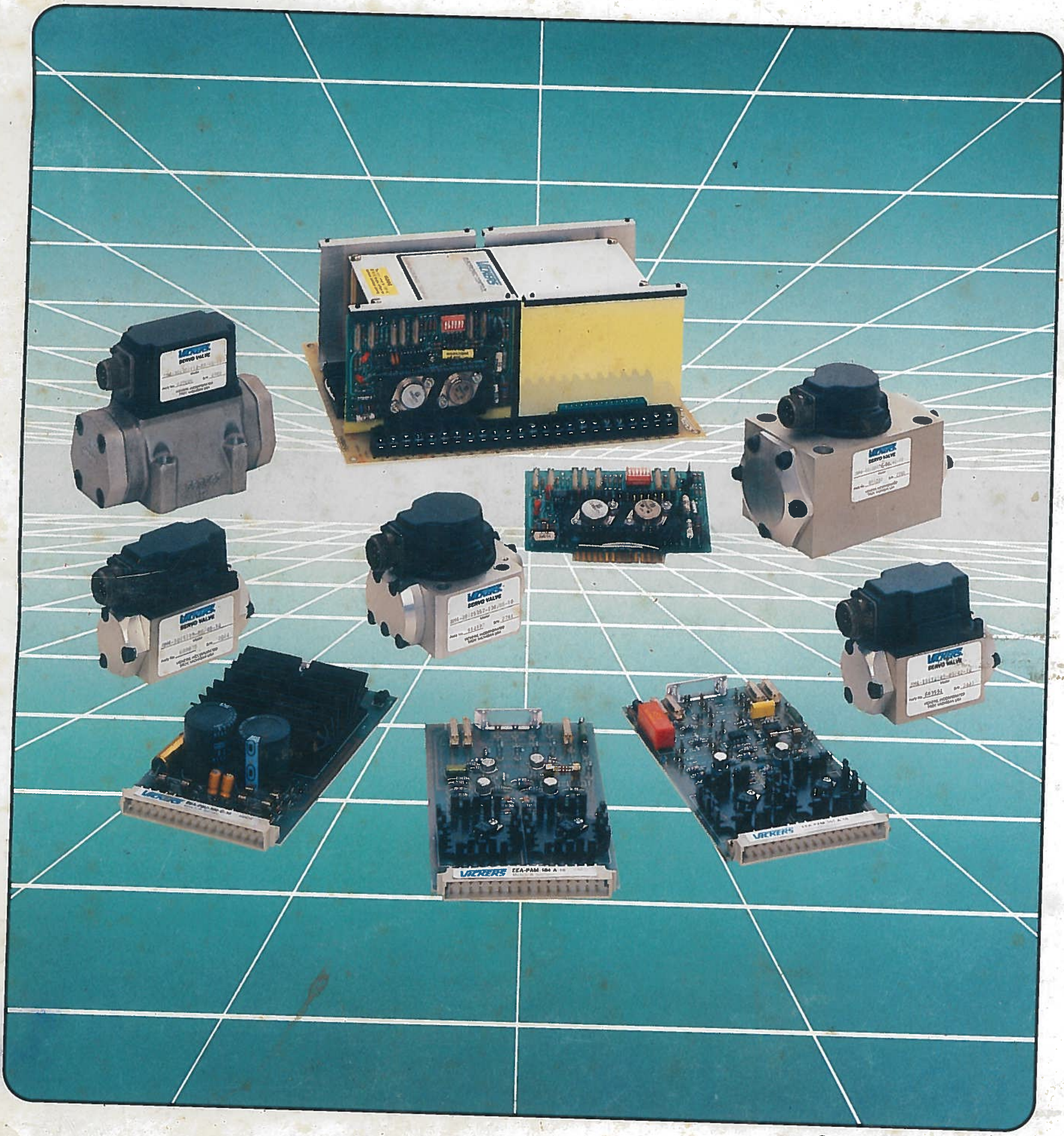
VICKERS®

# SM4 servo valves

## ...and how to apply them in closed loop systems




GB-C-2009-May 1989

A TRINOVA Company

Hydraulics, electrohydraulics, electronics: high performance products with quality standards second to none – for enhanced productivity and economy.

Vickers components and systems are used extensively for in-plant machinery, mobile vehicles, automotive equipment, aerospace and marine applications.

Presented by:

Vickers, Incorporated
P. O. Box 302
Troy, MI 48007-0302, U.S.A.
Telephone (313) 641-0100
Telex 62885696
Facsimile (313) 641-4680

GB-C-2009-5.89-15.0-FWS/WS

# Choose Vickers servo valves for best application, selection, and support

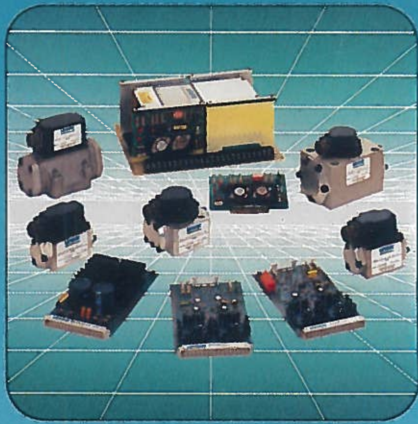
## Design or enhance your closed loop control for high performance, fast response and precise repeatability.

Introducing the SM4 series servo valves with traditional Vickers high quality and reliability.

## You can depend on the proper choice of controls with Vickers servo valve selection guidelines. . .

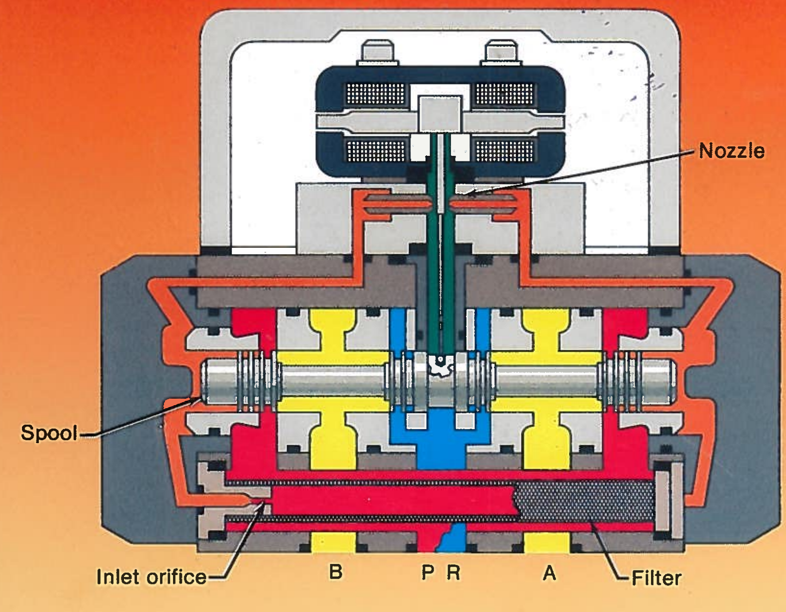
. . . because they include theoretical analysis and sizing calculations to ensure successful applications, supported by Vickers expertise available around the world.

## Vickers competitive edge: "complete hydraulic plus electronic" systems capability.



Cover Illustration:
SM4 servo valves, EM and EEA servo electronics.

SM4 functional schematic



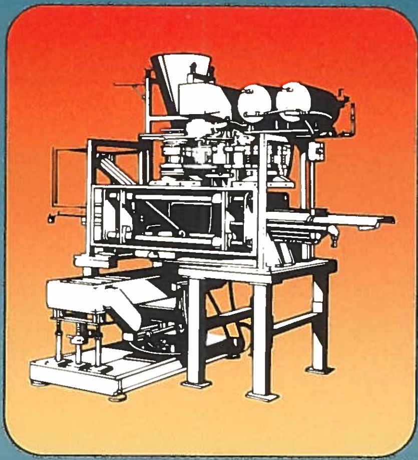

Supply pressure (and flow), shown in red, is filtered by a single element. Pilot flow, now in orange, is metered through two symmetrical inlet orifices. The first stage pressure/flow, shown in orange, is applied to the spool end areas and control nozzles. Drain pressure and control leakage, in green, is directed to return, shown in blue.

# Specify Vickers servo valves and electronics

## . . . for closed loop control with exact positional accuracy, repeatable velocity profiles, and predictable force or torque regulation.

- Lumber machinery
- Test and simulation
- Plastic injection and blow molding systems
- Die-casting machines and hydraulic press brakes
- Robotics and other factory automation
- Animation and entertainment equipment
- Oil exploration and other mobile vehicles





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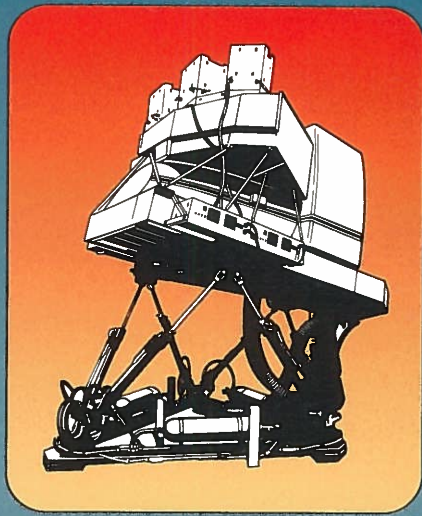

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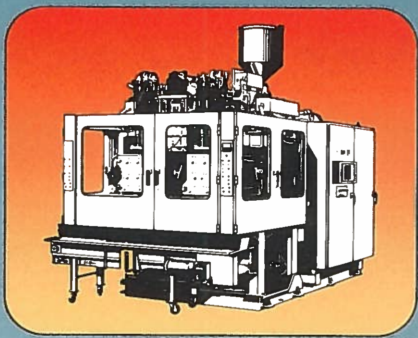

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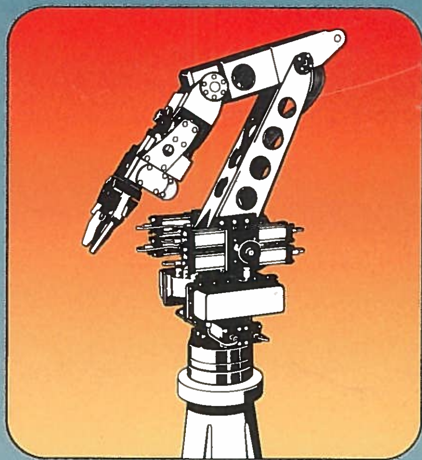

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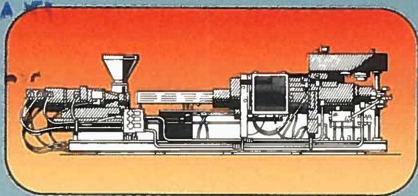

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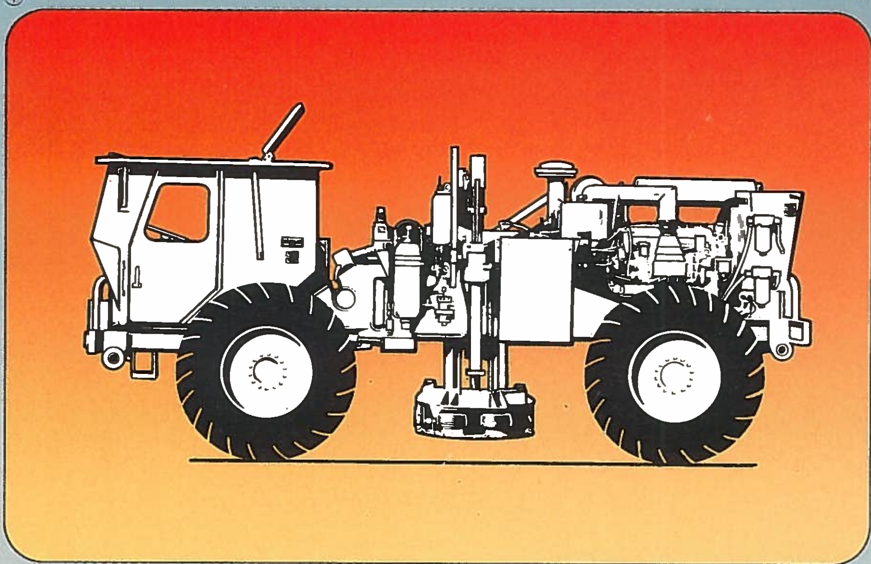

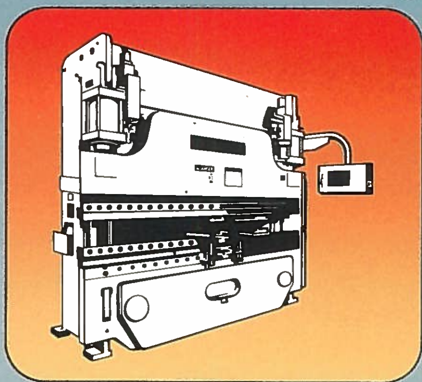

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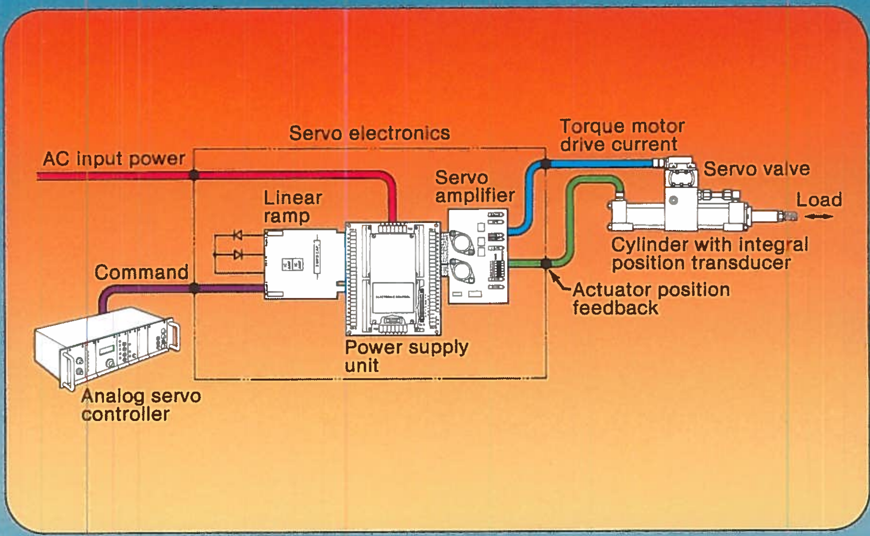
## Typical applications

1 *Seismic vibrators*
2 *Die casting machines*
3 *Blow molding machines*
4 *Plastic injection molders*
5 *Flight simulators*
6 *Robots*
7 *Press brakes*

# Typical servo system applications

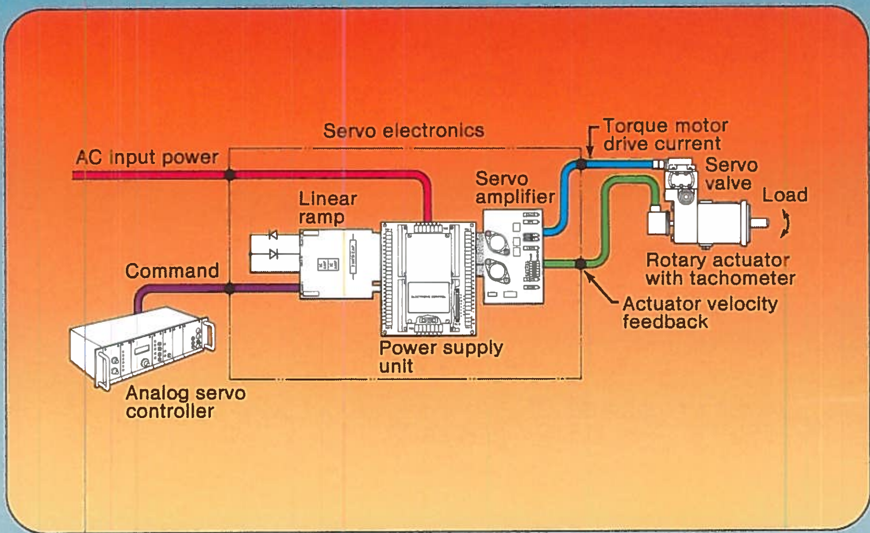
## Position control

The SM4 servo valve can be used with a hydraulic cylinder, position transducer, and electronics for infinite cylinder position control within ±0,025 mm (±0.001 in) or better.*



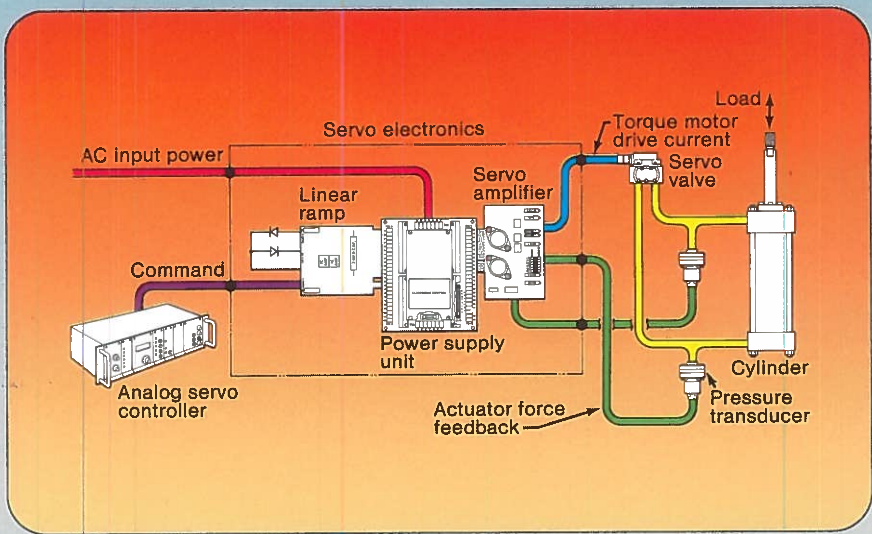

## Velocity control

The SM4 servo valve provides infinite proportional flow control for realtime velocity/acceleration profiles when applied with servo hydraulic motors, tachometers, and electronics. Closed loop error corrected to ±0,1 r/min (±0.1 rev/min) or better.*




## Force control

The SM4 servo valve offers exact load pressure/force control when used with pressure transducers or load cells, cylinders and electronics. Excellent system stability can be achieved with pressure to ± 0,07 bar (±1 psi) and load to ±1 % full scale.*

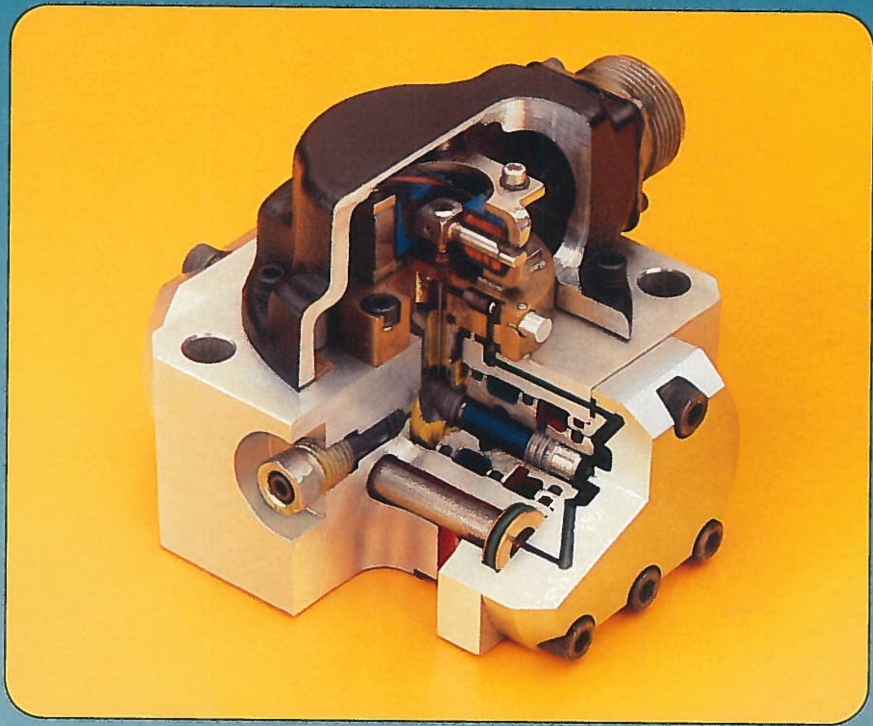



*Dependent on component selection and load characteristics.*

# Introducing Vickers SM4 servo valves

## The SM4 series offers a wide range of rated flow from 0 to 151 l/min at 70 bar $\Delta p$ (0 to 40 USgpm at 1000 psi $\Delta p$).

Vickers high performance SM4 servo valves incorporate field proven design features and improved manufacturing techniques for optimum system control.



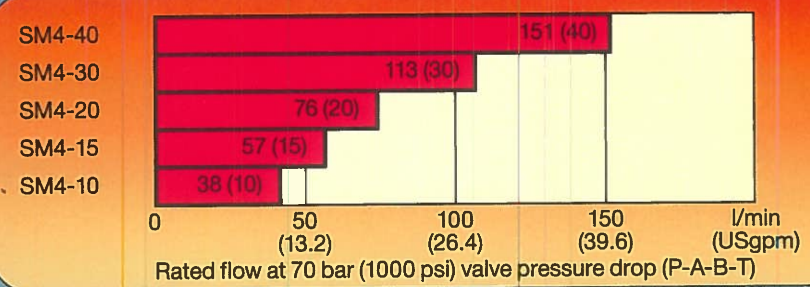

## The SM4 is a two stage, modular design flow control valve which can be manifold or subplate mounted.

The first stage consists of a symmetrical torque motor with dual coils and air gaps, flapper-nozzle pilot, and a centering feedback spring.

The second stage utilizes a four-way sliding spool in a sleeve arrangement with a null adjust, and integral pilot stage filter.

# SM4 servo valves offer 12 important features and outstanding benefits

## 1. Wide range of flow capability




Application benefit:

- Allows selection of valve size best suited for an application.

## 2. Standardized port circle, mounting patterns and adapter manifolds

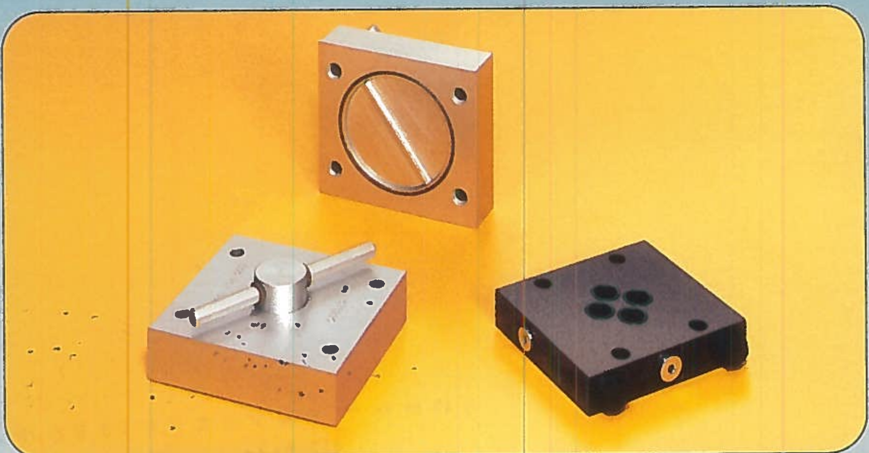
Standardized port mounting patterns

| Basic model | Port circle diameter | |
|---|---|---|
| | mm | inch |
| SM4-10 | 15,9 | 0.625 |
| SM4-15 | 23,8 | 0.937 |
| SM4-20 | 22,2 | 0.875 |
| SM4-30 | non-circular pattern | |
| SM4-40 | 44,4 | 1.750 |

Application benefit:

- Cost effective interchangeability for enhancement of existing systems.

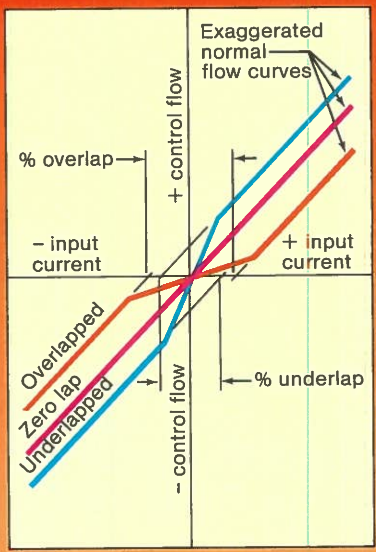
## 3. Simple interface to flushing valves and dual filter module

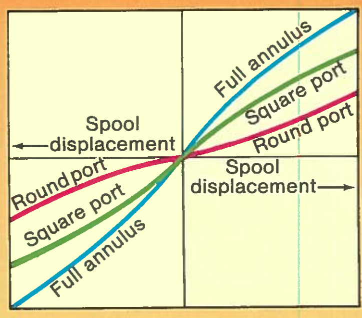


Application benefit:

- Maximum reliability and ease of maintenance against initial contamination levels.

## 4. Customized spool lap and sleeve porting

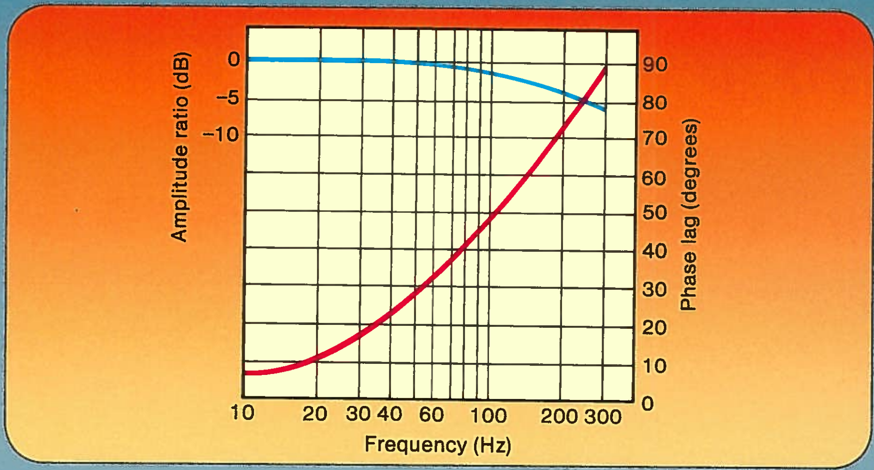



Application benefit:

- Specific flow control for special requirements.

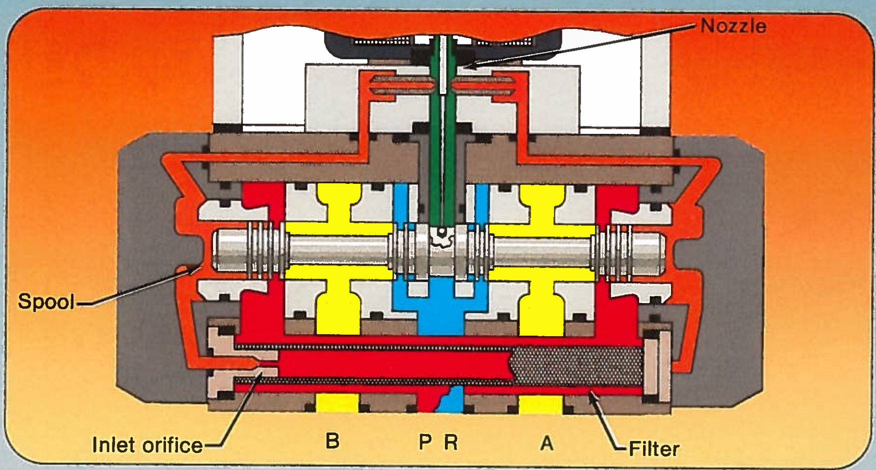
## 5. Higher frequency response available on request




Application benefit:

- Enhanced system bandwidth available for critical performance requirements.

## 6. Integral filter provides extra contamination protection to the first stage




Application benefit:

- Decreases possibility of hard-over failures.

## 7. Balanced dual coil, twin air gap, sealed torque motor

Application benefit:

- Very fast response to input signals for accurate control profiles.

## 8. Symmetrical design and construction

Application benefit:

- Dependable metering of control flow with minimum null shifts for more consistent machine operation.

## 9. Fluorocarbon seals as standard

Application benefit:

- Compatibility with most hydraulic fluids for reduced inventory requirements.

## 10. High strength alloy second stage body

Application benefit:

- Less weight, smaller size, excellent durability and long life.

## 11. Hardened stainless steel spool and sleeve with O-ring seals

Application benefit:

- Minimizes material erosion, eliminates spool binding, and ensures smooth operation.

## 12. External pilot port option with some models

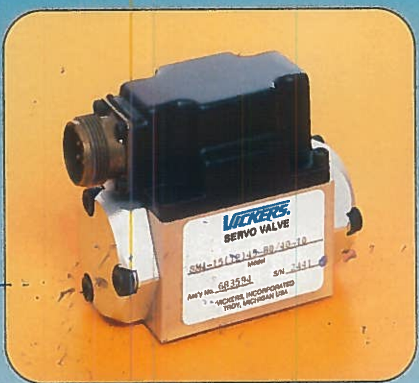
Application benefits:

- Allows first stage to utilize an external pilot source free of supply pressure fluctuations.
- Allows additional first-stage filtration to be provided for ultra-reliable operation.

# An innovative servo product line supported by complete electrohydraulic systems capability


## SM4-10
Rated flows: 3,8 – 38 l/min
(1 to 10 USgpm) in 5 sizes.
Rated pressure: 210 bar (3000 psi)


## SM4-30
Rated flows: 57 – 113 l/min
(15 to 30 USgpm) in 3 sizes.
Rated pressure: 140 bar (2000 psi)




## SM4-15
Rated flows: 3,8 – 57 l/min
(1 to 15 USgpm) in 7 sizes.
Rated pressure: 210 bar (3000 psi)


## SM4-40
Rated flows: 76 – 151 l/min
(20 to 40 USgpm) in 5 sizes.
Rated pressure: 210 bar (3000 psi)

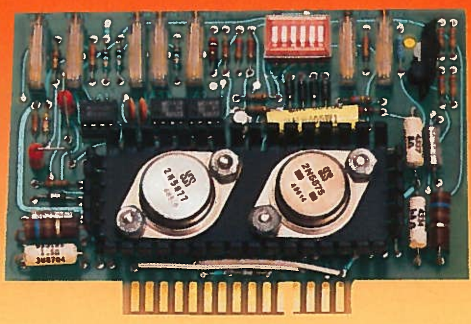

## SM4-20
Rated flows: 3,8 – 76 l/min
(1 to 20 USgpm) in 8 sizes.
Rated pressure: 210 bar (3000 psi)

## The complete range of standard valves

| Basic model | Port circle | Max. rated flow at 70 bar (1000 psi) Δp (P-A-B-T) | Typical performance at 210 bar (3000 psi) Frequency response at -3dB and ± 40 % rated current | Step response for 63 % of rated flow |
|---|---|---|---|---|
| | mm (in) | l/min (USgpm) | Hz | ms |
| SM4-10 | 15,9 (0.625) | 38 (10) | 110 to 80 | 4 to 6 |
| SM4-15 | 23,8 (0.937) | 57 (15) | 110 to 30 | 4 to 8 |
| SM4-20 | 22,2 (0.875) | 76 (20) | 110 to 30 | 4 to 10 |
| SM4-30 | Non-circular* | 113 (30) | 22 to 18 | 11 to 20 |
| SM4-40 | 44,4 (1.750) | 151 (40) | 24 to 18 | 9 to 15 |

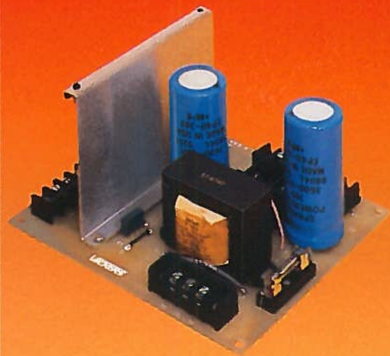
* *See page 25 for port configuration.*

# EM servo electronics



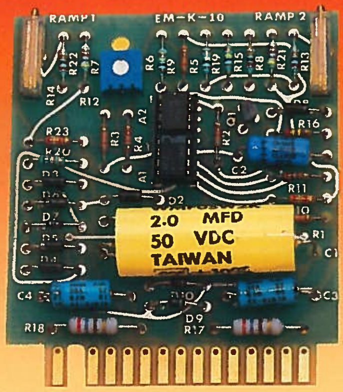
## EM-D-20 servo amplifier

includes a summing junction for inputs, voltage amplifiers, current driver stage and limiters suitable for closed loop position, velocity and force control.



## EMRS-A-11 power supply

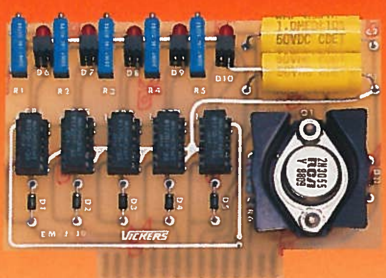
is a ±12 V DC power supply for one servo amplifier module. It also provides the interface mounting for the EM-D-20 series amplifier, and the proper excitation voltage and connections to external circuits.




## EM-K-10 ramp module

converts step changes in input signals to ramped signals for smooth transition from one operating level to another. When used with an EM-D-20 amplifier, the ramp module provides a means of controlling velocity in positioning systems, acceleration and deceleration in velocity control systems, and rate of pressure change in force control systems. The ramp module may be installed in either an EMRS-A-11 or an EMP-A-20 power supply unit.



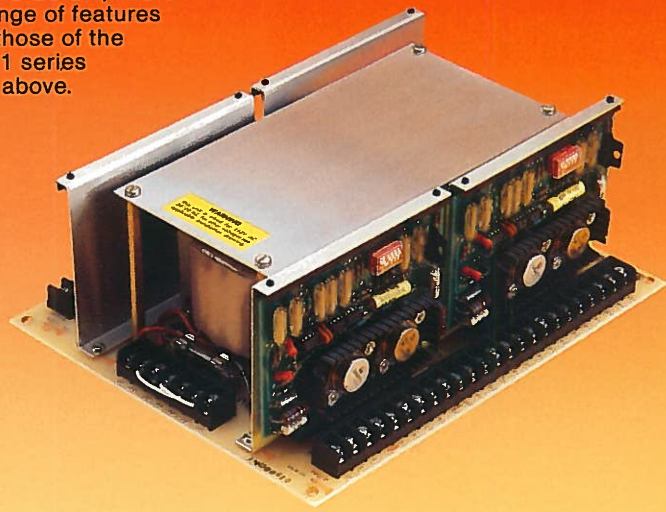



## EM-J-10 programmer module

provides up to five preset command signals. When used with an EM-D-20 amplifier, the module provides a means of presetting and selecting a variety of positions, velocities or forces in closed-loop servo systems.

## EMP-A-20 power supply

is a ±12V DC power supply for up to four EM-D-20 amplifiers. It has a range of features similar to those of the EMRS-A-11 series described above.



# EEA servo electronics

## EEA-PAM-101-A-10 Eurocard servo amplifier

incorporates a PI controller for proportional and integral amplifier circuits. A reset relay is used with the integral function, and an adjustment potentiometer is provided for dither signals. This amplifier can be card or rack mounted for use in typical closed loop applications.

## EEA-PAM-104-A-10 Eurocard servo amplifier

allows for constant input current control, irrespective of temperature changes in the valve torque motor coils. The input signal can be adjusted with a card mounted potentiometer. Additional potentiometers allow for adjustment of dither and balance in closed loop systems. This amplifier can also be card or rack mounted and used in conjunction with the EEA-PSU power supply card.

## EEA-PSU-106-*-10 Eurocard power supply card

provides regulated voltages from ±5 to ±24 V DC, dependent on model type. This power supply board is used with EEA-PAM-101/104 amplifiers and can be card or rack mounted.

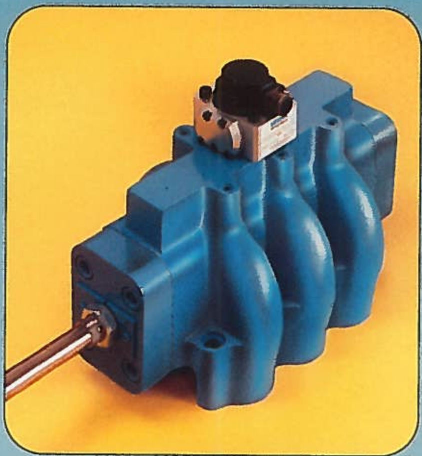
# Additional products for total systems capability

- System components such as microprocessor controls, single and multiple pumps, pressure, flow, check and directional controls, screw-in and slip-in type cartridge valves, hydraulic motors and cylinders, electronics, as well as packaged systems and components
- Direct-operated and piloted proportional valves, with and without feedback transducers
- Digital and closed loop servo-control packages with integrated electronics

*① Cylinder with integral position transducer for servo actuator applications*
*② Xpert SM4-20 DCL (digital and closed loop) servo valve*
*③ High flow three-stage servo valve with SM4-20 (analog) pilot and LVDT feedback of main spool position*
*④ Xpert SM4-40 DCL servo valve*
*⑤ High flow three-stage servo valve with Xpert SM4-20 DCL (digital) pilot and LVDT feedback of main spool position*
*⑥ KSDG4V-3 high dynamic performance proportional valve with feedback transducer and power amplifier*


②


④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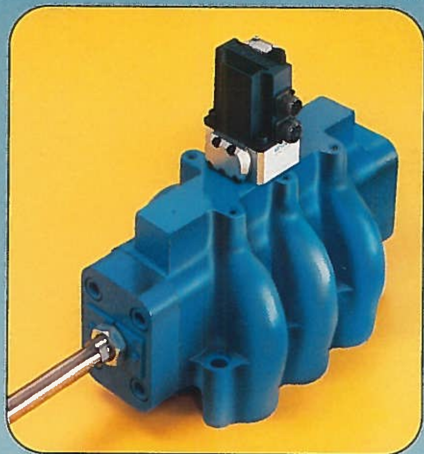
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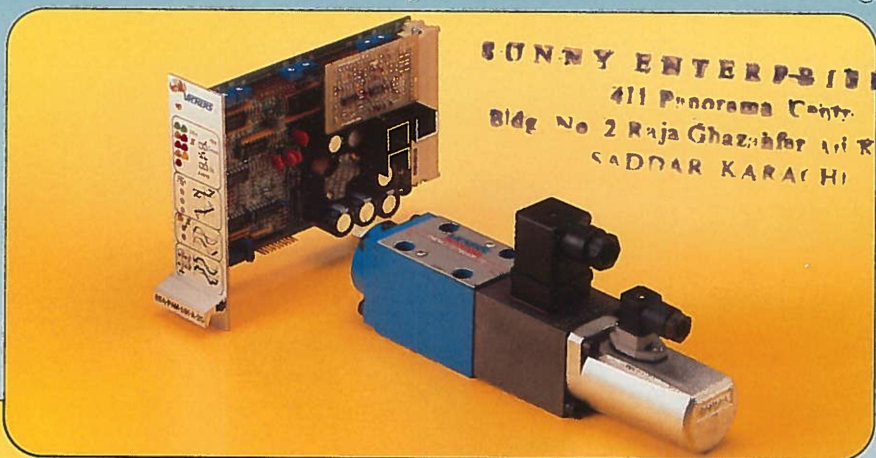

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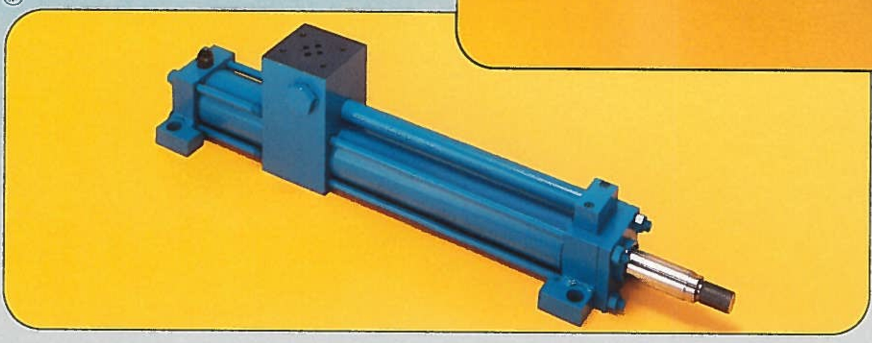


Please contact your Vickers representative for specific catalogs, bulletins, and technical information leaflets.

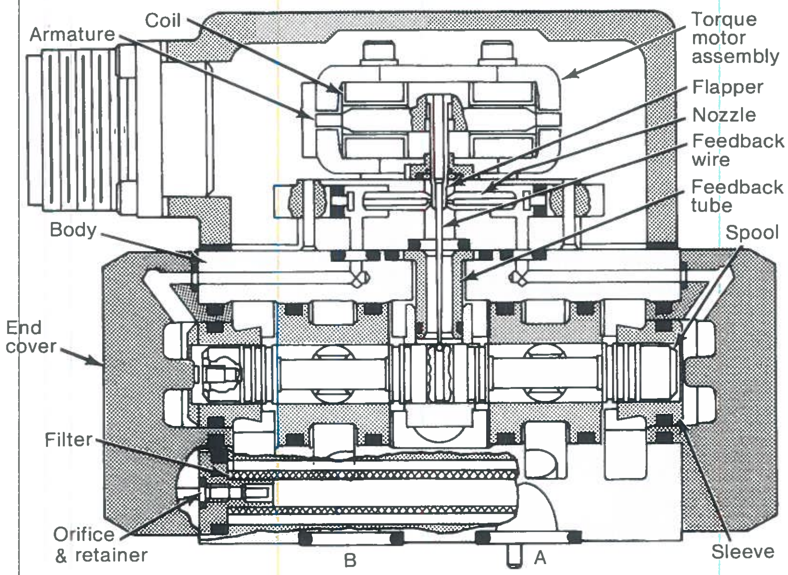
# Vickers SM4 series servo valves

## A complete product line that performs to the most critical demands of today's automated machinery.

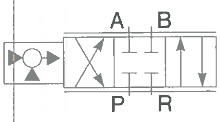
# Contents

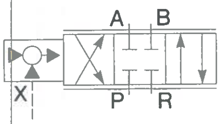
# SM4 series

## Typical cross section



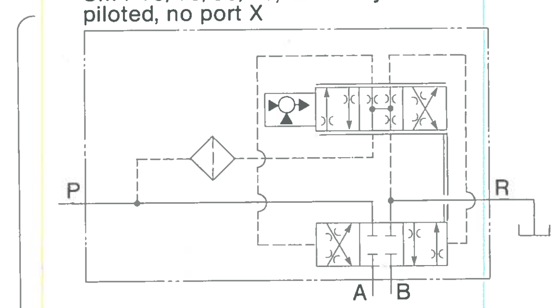

## Functional symbols



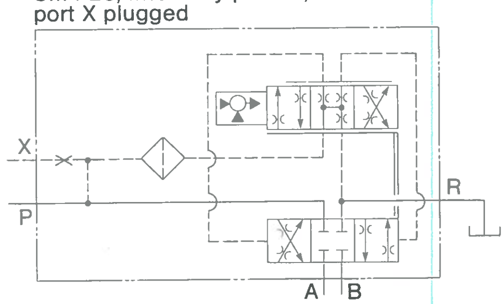




## Detailed symbols

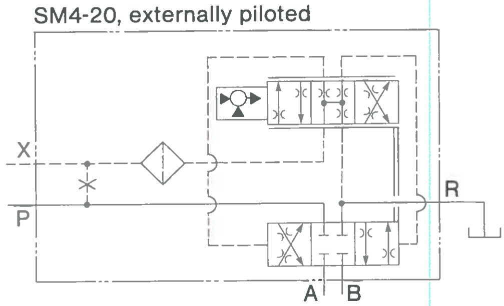
SM4-10/15/30/40, internally piloted, no port X




SM4-20, internally piloted, port X plugged

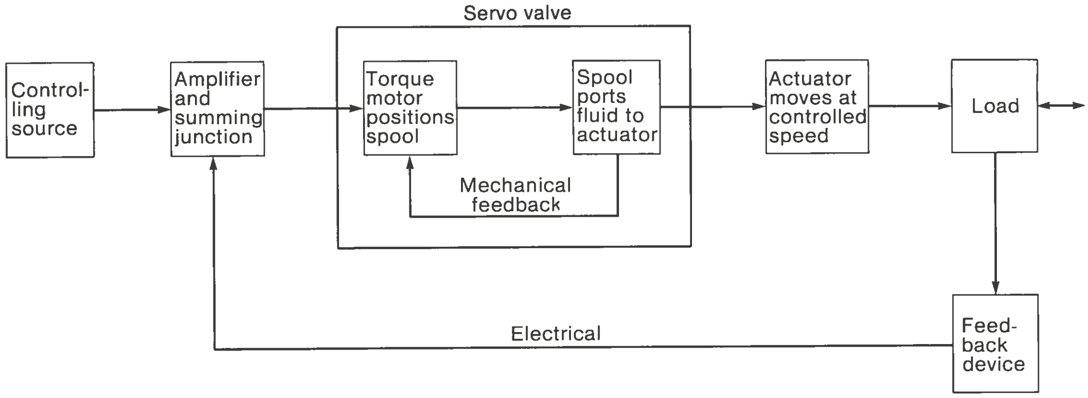



SM4-20, externally piloted



# Understanding servo valves for closed loop control

## Functional servo diagram




A servo valve is a closed center, four-way proportional flow control.

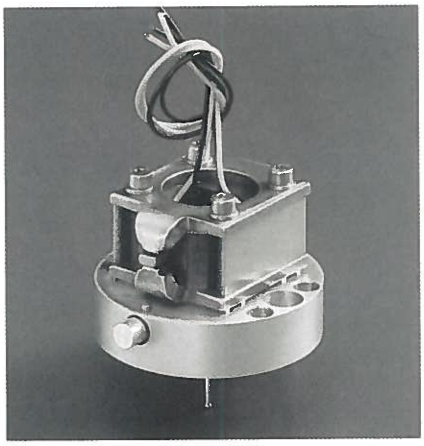
An electrical input to the first-stage torque motor positions the second-stage spool to control flow proportional to input current.

The second-stage spool position is achieved by internal force feedback.

Excellent hysteresis and linearity results in repeatable and accurate actuator velocity to a commanded position.

System control is completed through an electrical feedback device to the summing junction and servo amplifier.

## The Vickers SM4 servo valve and how it works



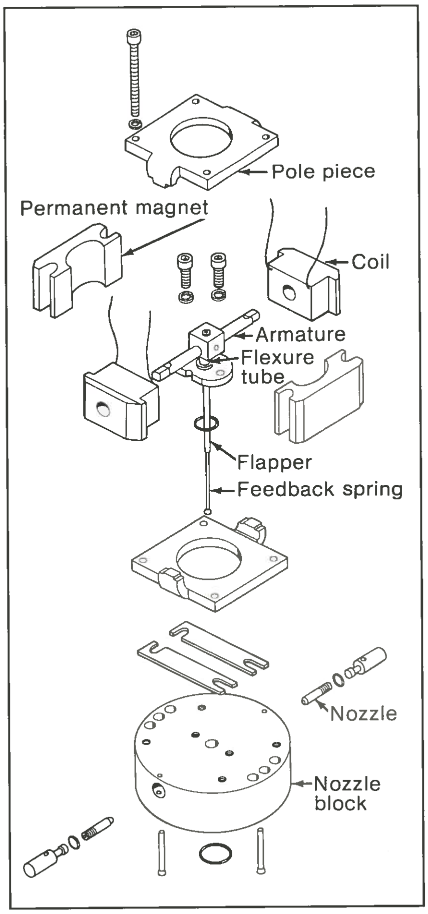
The two stage servo valve with force feedback is capable of performance superior to that of any other design. Meticulous assembly and measured quality ensure fast, dependable electrohydraulic amplification.

## SM4 first stage

The torque motor converts a low level electrical current signal to rotary motion of the armature and flapper assembly.

The pilot stage directs pressurized hydraulic flow as a result of flapper motion.

Pole pieces and permanent magnets provide a network for the magnetic flux in each air gap.




Current applied to the coils creates a torque on the armature.

The nozzle block allows for precision spacing of the control nozzles to the flapper.

# The servo valve first stage is an electrical controller with a hydraulic amplifier and force feedback.

## First stage operation

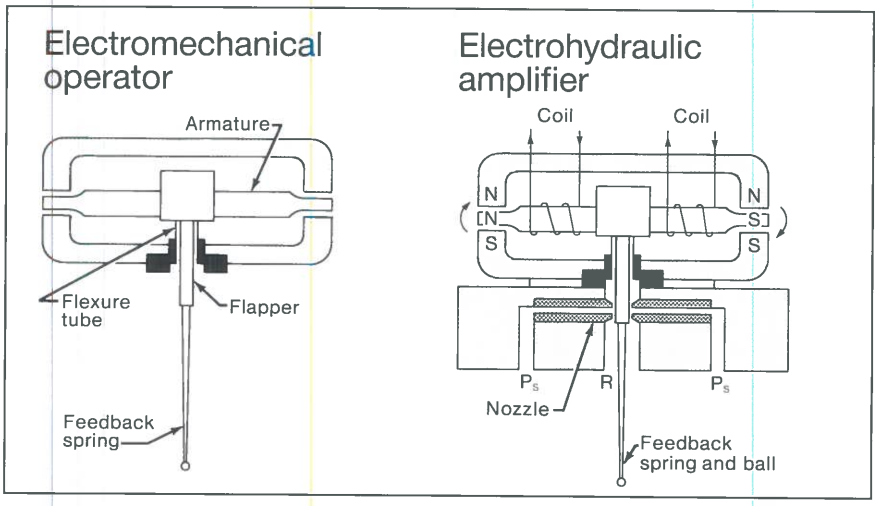
The first stage controller converts low level current signals to a mechanical force or motion.

The flexure tube supports the armature and also acts as a fluid seal between hydraulic and electrical sections.

Attached at the center of the armature are the flapper and feedback spring that extend down through the flexure tube.

An input signal is applied to the coils through an electrical connector, polarizing the armature ends and creating a rotational torque on the armature.

The flexure tube acts as a spring, limiting the flapper motion between two nozzle openings.




Hydraulic amplification results as pilot flow from $P_s$ is supplied through an integral filter and orifice assembly to the nozzles for control of a greater second stage flow proportional to input current.

Internal feedback is achieved by the use of a simple cantilever spring attached to the flapper, with the ball end closely fitted to the second stage spool.

# The servo valve second stage controls hydraulic flow and contains the pilot stage filter.

## SM4 second stage

Output flow is controlled by a four-way closed center spool that slides within a sleeve.

Spool movement uncovers openings in the sleeve to meter flow to the control ports.

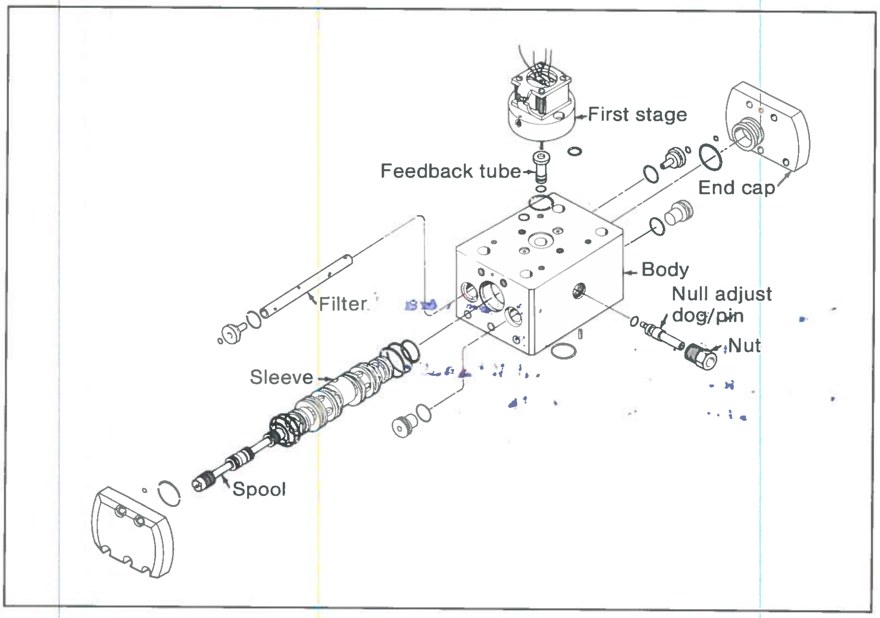
The positioning of the spool relative to these metering slots provides precise control flow.

The modular pilot stage is precision mounted to the body for positioning of the feedback ball in the spool.

The null adjust pin and self locking nut allow for dependable sleeve adjustment of control flow around the center or null position.

A fine mesh filter is located inside the second stage body to protect the pilot stage from contamination.

Various spool/sleeve sizes allow for the proper selection of rated flow and performance.




Spool position and output flow are proportional to the level of input current.

Actual load flow to the actuator depends on supply pressure, load pressure drop, input current, and the flow rating or size of the servo valve.

# Complete servo valve control flow for optimum system performance

## Second stage operation

Electrical current causes the flapper to move toward the nozzle on the right side.

Pilot pressure on the spool end area causes spool movement to the left and control flow out of port A.

The feedback spring bends and applies a force to the flapper, which tends to recenter the flapper between the nozzles.

Spool positioning occurs at the point at which the spring feedback force equals the torque motor force induced by the input current.

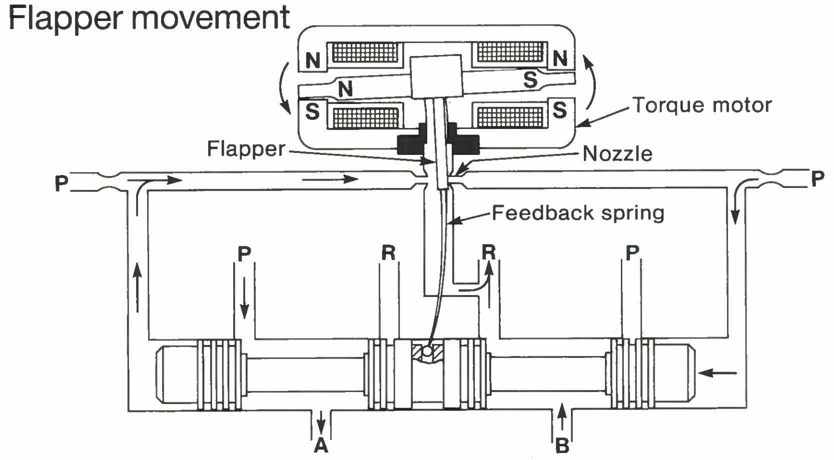
The spool stops at this position, and the flapper is now centered until the input current changes to a new level.

A reverse electrical input current signal results in flow to port B.

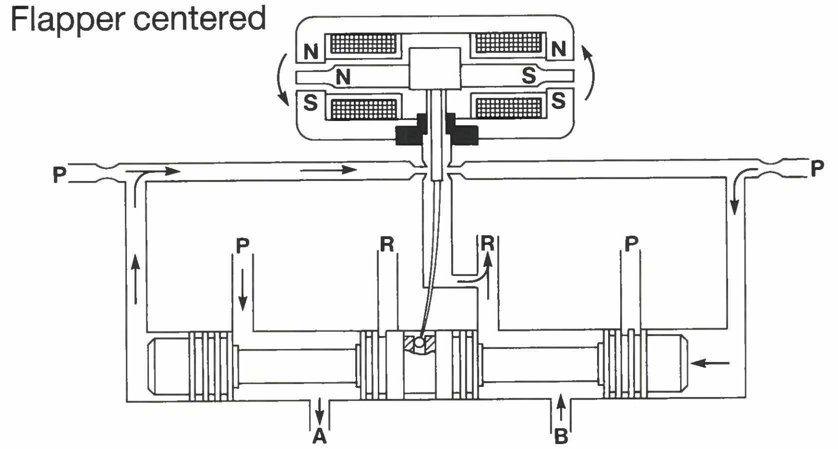
Optimum flow control is achieved by force feedback.

With constant supply pressure and flow to the servo valve, output control flow is infinitely proportional to the input current.

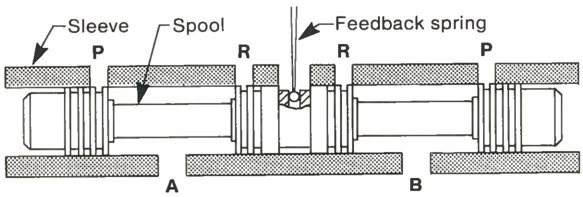
Flapper movement




Flapper centered

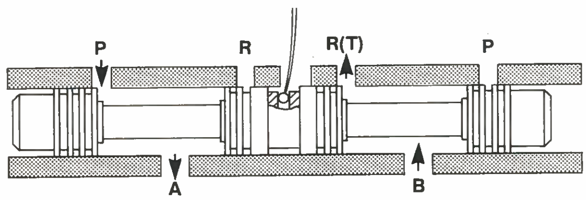



Closed center spool/sleeve




Spool centered at null with the control lands blocking A and B

Movement of spool



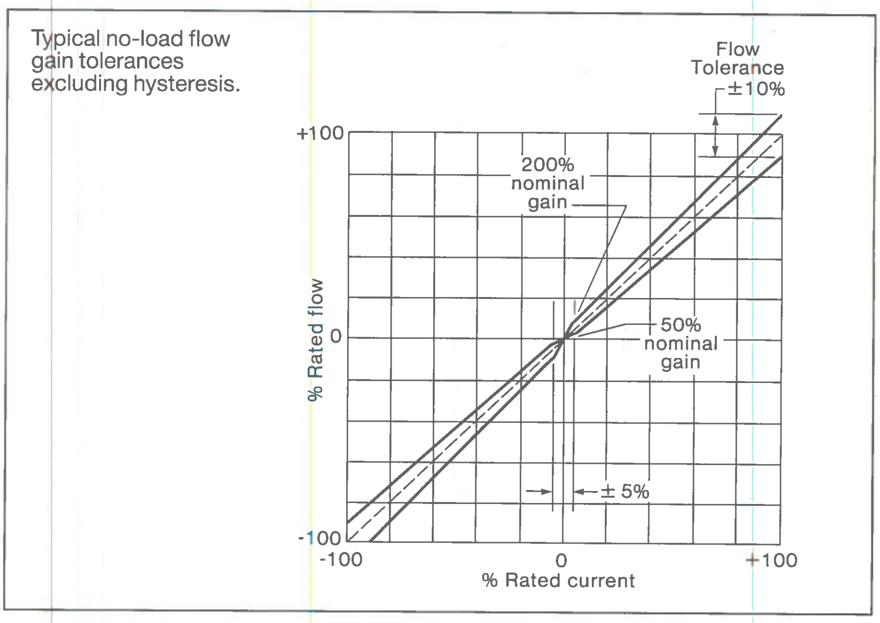

Spool motion opens flow passage from P to A and B to T

# SM4 operating data

All data is typical, based on a large sample of actual tests at 30 cST (141 SUS) and 48°C (120°F).

| Rated flow, and total internal leakage at null | | | | |
|---|---|---|---|---|
| Standard model | Rated flow* | | Total null leakage | |
| | l/min | USgpm | l/min | USgpm |
| SM4-10 | 38 | 10 | 0,95 | 0.25 |
| SM4-15 | 57 | 15 | 0,95 | 0.25 |
| SM4-20 | 76 | 20 | 0,95 | 0.25 |
| SM4-30 | 113 | 30 | 1,50 | 0.40 |
| SM4-40 | 151 | 40 | 1,50 | 0.40 |
| Flow gain, null region | | | 50% to 200% nominal within ±5% rated current | |

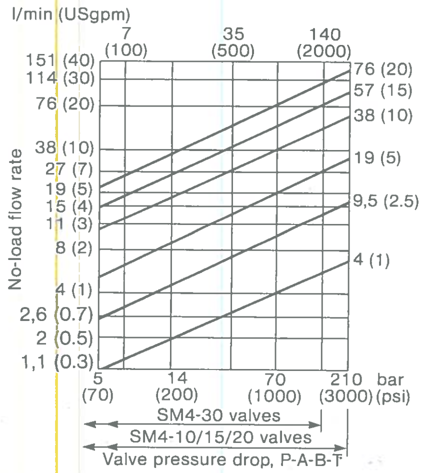
## Flow gain, normal region for standard models

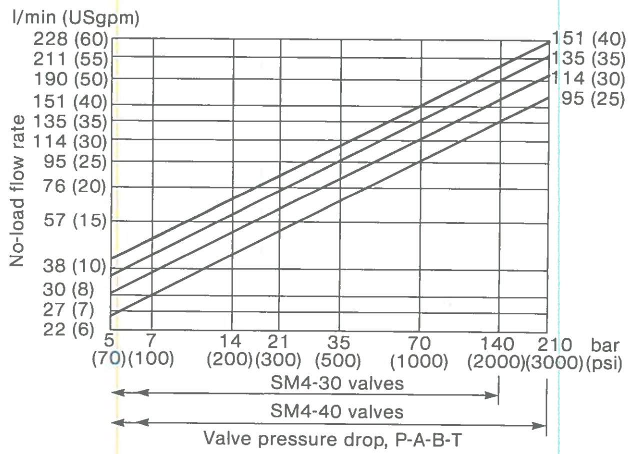



| | |
|---|---|
| Hysteresis around null | < 2% of rated current |
| Symmetry error | < 5% of rated current |
| Linearity error | < 5% of rated current and <10% at maximum rated flow |
| Threshold | <0.5% of rated current |

*Maximum flow at 70 bar (1000 psi) Δp and typical leakage at 210 bar (3000 psi).

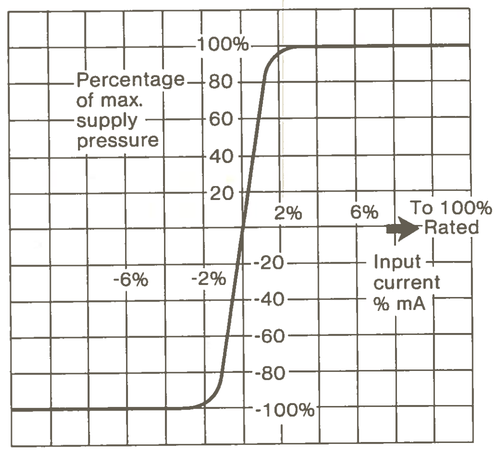
## Change in rated flow with valve pressure drop



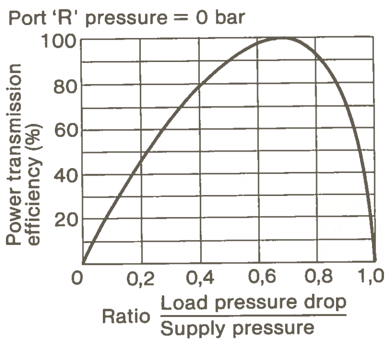
| | |
|---|---|
| Rated supply pressure:<br>SM4-10/15/20/40<br>SM4-30 | <br>210 bar (3000 psi)<br>140 bar (2000 psi) |
| Maximum supply pressure*:<br>SM4-10/15/20/40<br>SM4-30<br>*Subject to engineering approval | <br>350 bar (5000 psi)<br>210 bar (3000 psi) |
| Minimum supply pressure | 14 bar ( 200 psi) |
| Proof pressure:<br>At supply port<br>At return port | <br>150% max. rated pressure<br>100% max. rated pressure |
| Burst pressure, return port open | 250% max. rated pressure |

Pressure gain – the change of load pressure drop with input current, with no valve flow and closed control ports.




| | |
|---|---|
| Pressure gain, null region: | >30% of supply pressure per 1% of rated current |
| Null shift, nominal:<br>– temperature change<br>– supply pressure change<br>– return pressure change<br>– acceleration | <br><1.5%/56°C (100°F)<br>< 2%/70 bar (1000 psi)<br>< 2%/35 bar ( 500 psi)<br>< 2%/10g |
| Vibration tested, 5 Hz to 2000 Hz at 10g and double amplitude along each axis | No damage to components |
| Shock tested, up to 150g along all axes | No damage to components |
| Endurance tested, to ISO 6404 | No degradation from standard valve performance limits |
| Hydraulic fluids, temperature ranges, and filtration recommendations | See page 55 |
| Installation (start-up) | See page 55 |
| Installation dimensions | See pages 24 and 25 |
| Mass (weight):<br>SM4-10/15<br>SM4-20<br>SM4-30<br>SM4-40 | <br>0,68 kg (1.5 lb)<br>1,05 kg (2.3 lb)<br>1,9 kg (4.1 lb)<br>2,8 kg (6.2 lb) |

Power transmission efficiency – the maximum power envelope expressed as a percentage.




Servo performance is optimum when valve pressure drop is one third of supply pressure. Consider overall hydraulic efficiency in sizing system heat exchangers.

# SM4 performance data

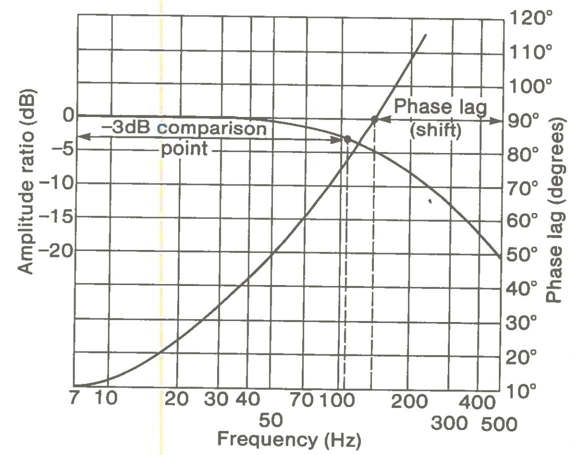
All data is typical with actual performance limits defined by Vickers test procedure TP7841 or TP7795.

## Frequency response

– the relationship of no-load control flow to input current with a sinusoidal current sweep at constant amplitude over a range of frequencies. Expressed in frequency (Hz), amplitude ratio (dB), and phase shift (degrees).

– 3db ratio is the standard comparison point, and 90 degree phase shift is a measure of the servo valve bandwidth.

Frequency response is lower for increased valve size because of changes in internal design, i. e. spool/sleeve diameters, flapper nozzle assembly, feedback spring rates.



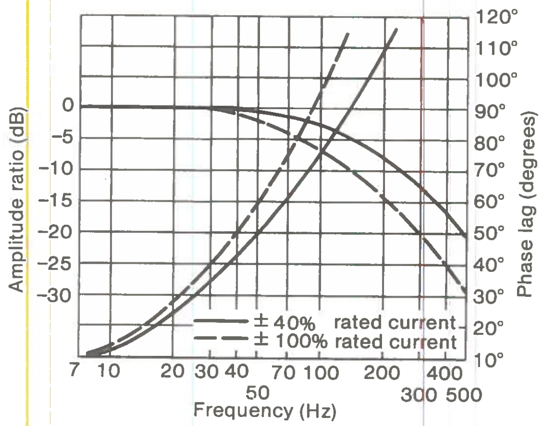

Vickers SM4 torque motors are magnetically stabilized for reliable servo valve performance from 14 – 210 bar (200 – 3000 psi) operating pressures.

## Typical frequency response curves for standard models

Note: SM4-10/15/20/40 shown at 210 bar (3000 psi), SM4-30 at 140 bar (2000 psi)

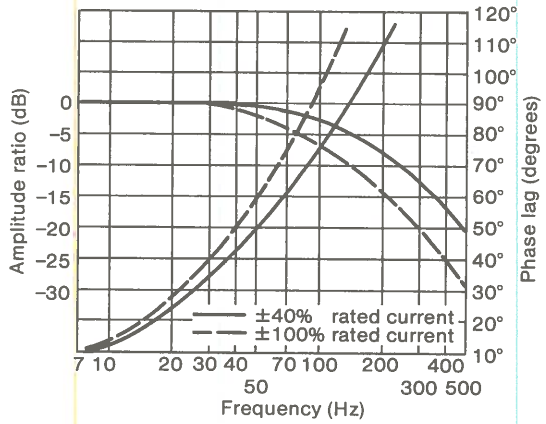
### SM4-10/15/20

3,8 and 9 l/min (1.0 and 2.5 USgpm)



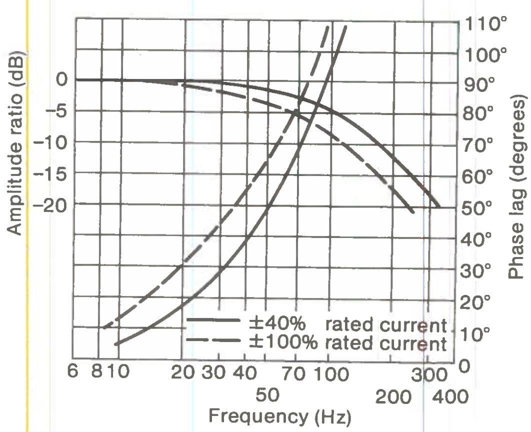

### SM4-10/15/20

19 and 28 l/min (5.0 and 7.5 USgpm)



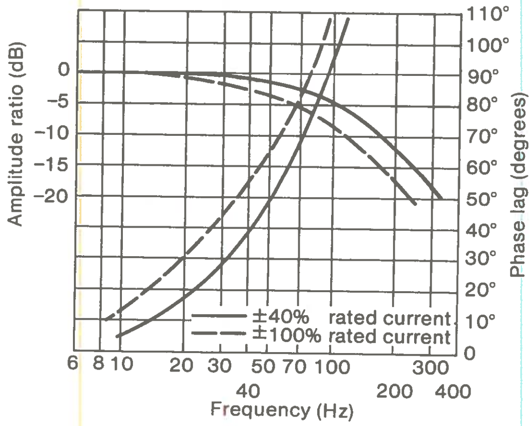

### SM4-10

38 l/min (10 USgpm)



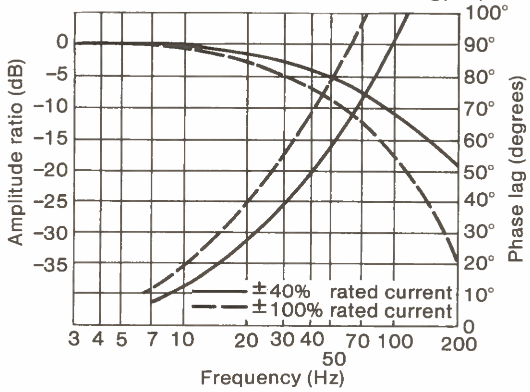

### SM4-15

38 l/min (10 USgpm)



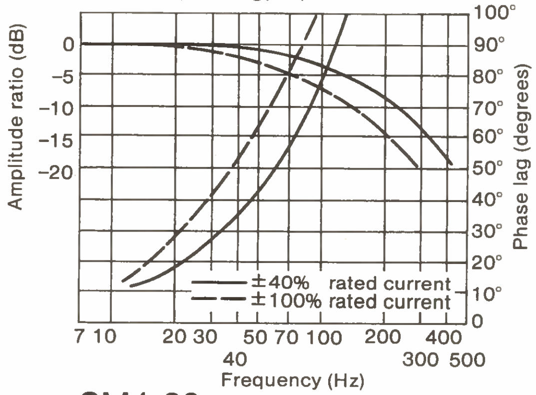
## SM4-15

47 and 57 l/min (12.5 and 15 USgpm)



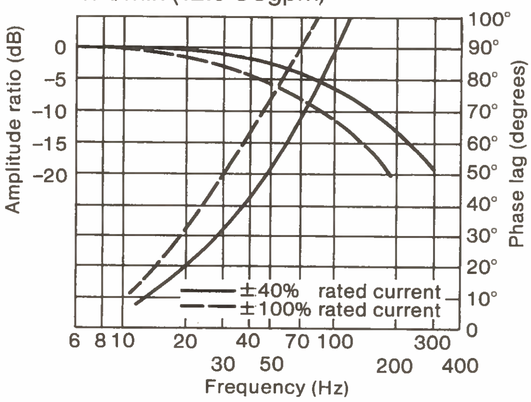

## SM4-20

38 l/min (10 USgpm)



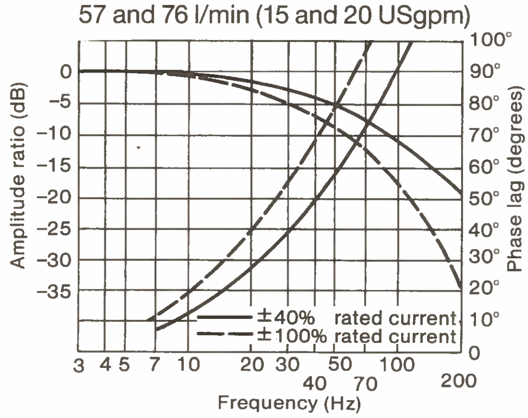

## SM4-20

47 l/min (12.5 USgpm)



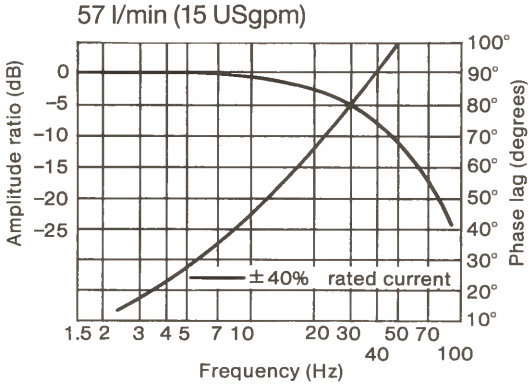

## SM4-20

57 and 76 l/min (15 and 20 USgpm)



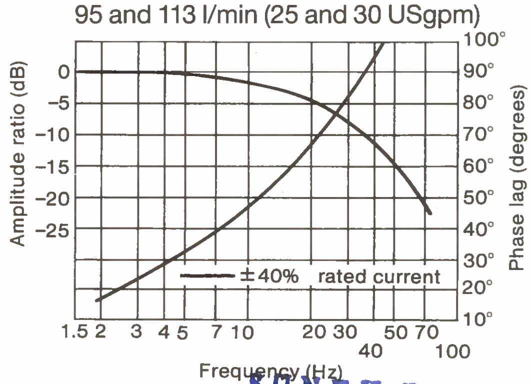

## SM4-30

57 l/min (15 USgpm)




## SM4-30

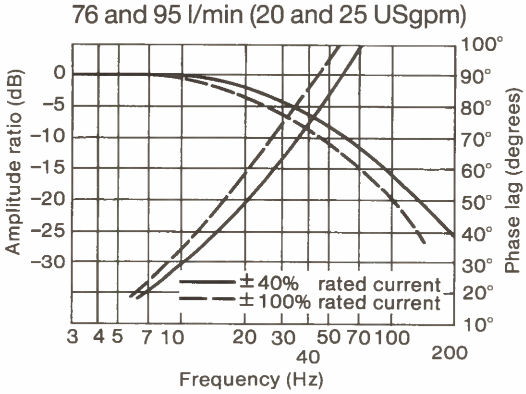
95 and 113 l/min (25 and 30 USgpm)





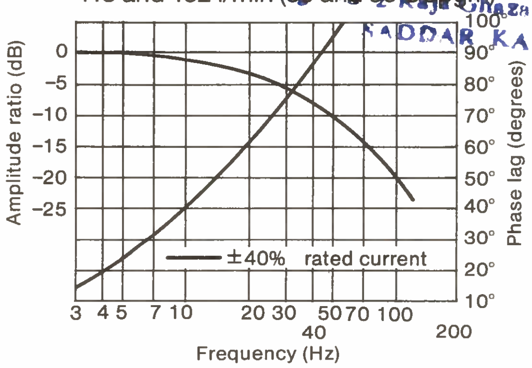

## SM4-40

76 and 95 l/min (20 and 25 USgpm)




## SM4-40

113 and 132 l/min (30 and 35 USgpm)

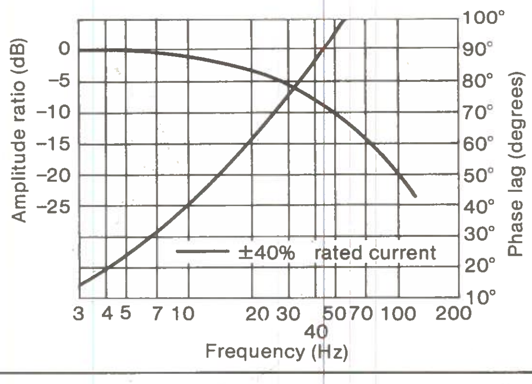


# SM4 performance data

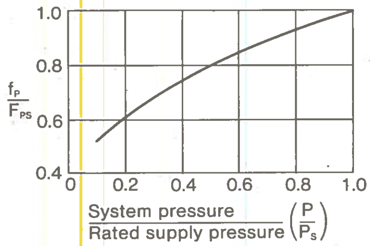
## Typical frequency response curves

### SM4-40

151 l/min (40 USgpm)




## Changes in frequency response with pressure




$f_P$ = frequency @ 90 phase lag at any pressure P

$f_{PS}$ = frequency @ 90 phase lag at rated supply pressure $P_S$

SM4-10/15/20/40 $P_S$ = 210 bar (3000 psi)

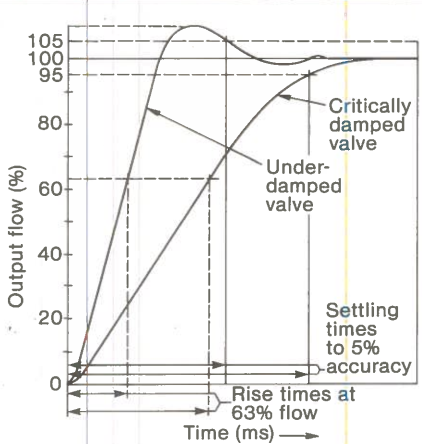
SM4-30 $P_S$ = 140 bar (2000 psi)

Example:

Assuming a 151 l/min (40 USgpm) SM4-40 valve is to be used at 165 bar (2400 psi) pressure P, variation in response with supply pressure = $\frac{P}{P_S}$ = 0.8. From curve above, $f_{PS}$ = 45 Hz; therefore, $f_P$ = 45 x 0.8 = 36 Hz.

## Step response

Step response – the typical rise time to achieve a percentage of control flow output. Settling time is that in which transient flow fluctuations diminish to a stated level.



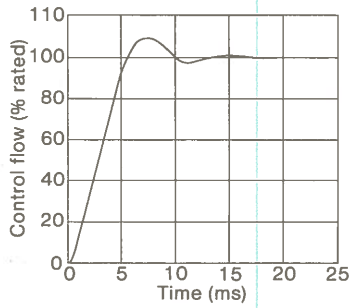

## Typical step response for standard models

Note: SM4-10/15/20/40 shown at 210 bar (3000 psi), SM4-30 at 140 bar (2000 psi)

## Typical step response curves

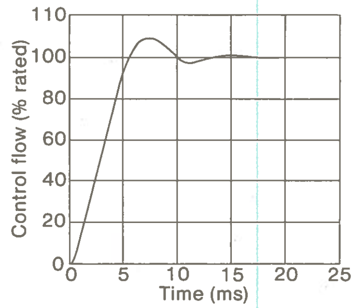
### SM4-10/15/20

3,8 and 9 l/min (1.0 and 2.5 USgpm)



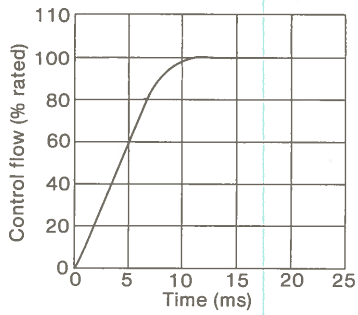

### SM4-10/15/20

19 and 28 l/min (5.0 and 7.5 USgpm)



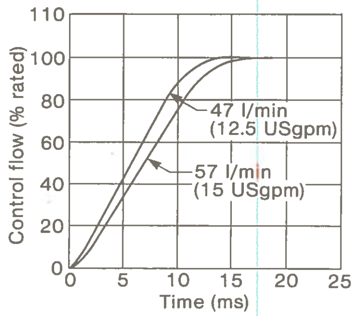

### SM4-10/15/20

38 l/min (10 USgpm)




### SM4-15/20

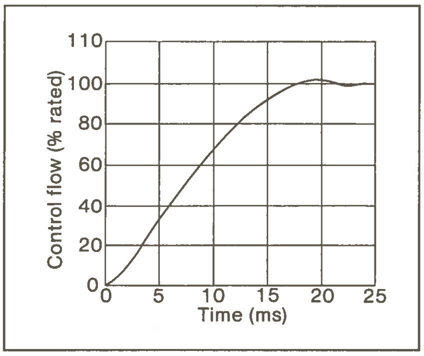
47 and 57 l/min (12.5 and 15 USgpm)



## Typical step response curves

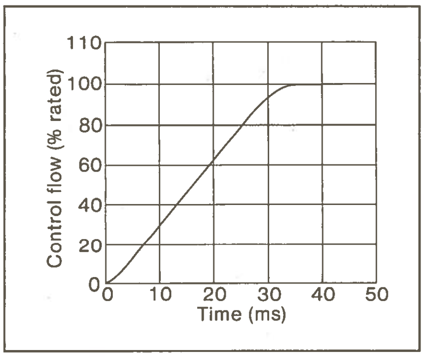
### SM4-20

76 l/min (20 USgpm)



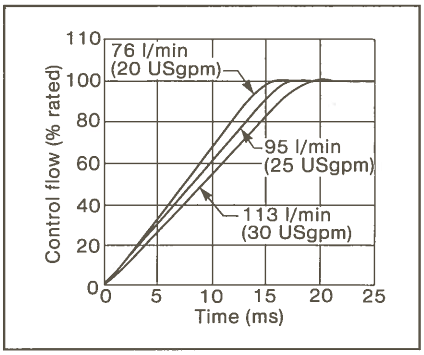

### SM4-30

57,95, and 113 l/min
(15, 25 and 30 USgpm)



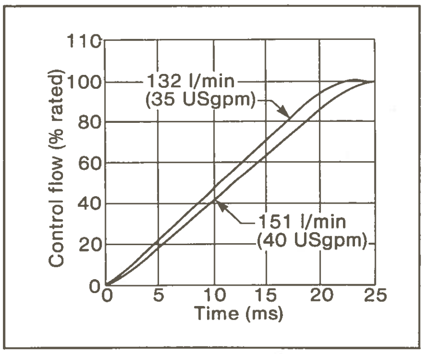

### SM4-40

76, 95, and 113 l/min
(20, 25, and 30 USgpm)




### SM4-40

132 and 151 l/min (35 and 40 USgpm)




# SM4 electrical data

Select coil resistance and connections for compatible interface to servo electronics.

Recommended coil resistance is shown in bold print.

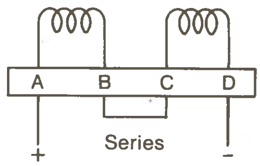
| Nominal resistance per coil at 21°C (70°F) | Rated current mA: Single, parallel or differential | Rated current mA: Series connection |
|---|---|---|
| Standard Coil resistance selection | | |
| Ohms | mA | mA |
| **20** | **200** | **100** |
| **80** | **40** | **20** |
| 30 | 100 | 50 |
| 200 | 15 | 7.5 |
| Optional | | |
| 80 | 50 | 25 |
| 140 | 40 | 20 |
| 200 | 20 | 10 |
| 300 | 30 | 15 |
| 1000 | 10 | 5 |
| 1500 | 8 | 4 |

Example of recommended coil configurations:

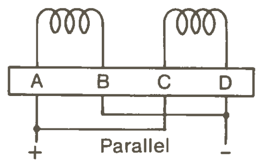
| Characteristic | Single | Series | Parallel | Differential |
|---|---|---|---|---|
| Coil resistance (Ohms) | 80 | 160 | 40 | 80 |
| Rated current (mA) | ± 40 | ± 20 | ± 40 | ± 40 |
| Nominal voltage (Volts) | ± 3.2 | ± 3.2 | ± 1.6 | ± 3.2 |
| Approx. inductance (Henrys) | 0.22 | 0.66 | 0.18 | 0.34 |

The two coils of the valve can be connected in any of the ways shown in the diagram below by varying the assembly inside the mating connector (Amphenol No. MS3016A-14S-2S).

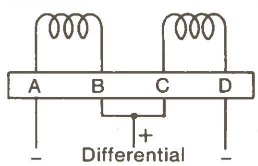
### Electrical polarity for control flow out of port B



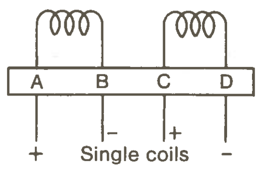

**Series:**
A+, D–
Connect B and C.



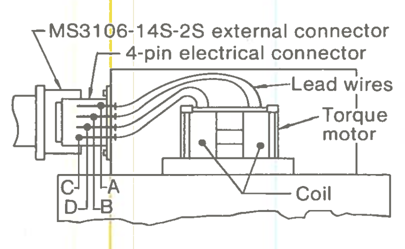

**Parallel:**
A+, C+
B–, D–
Connect A and C.
Connect B and D.




**Differential:**
A–, D–
B+, C+
Connect B and C.
BC–, current BA > CD
BC+, current CD > BA

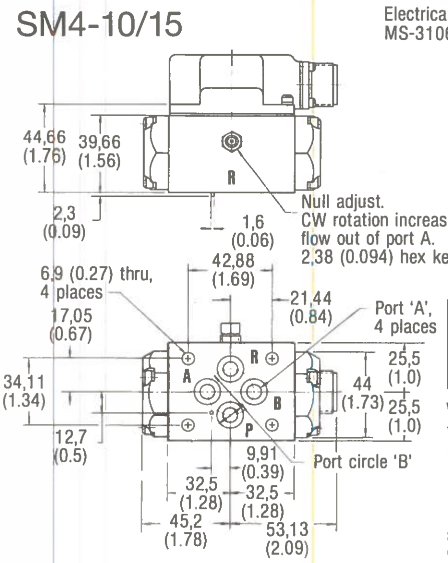


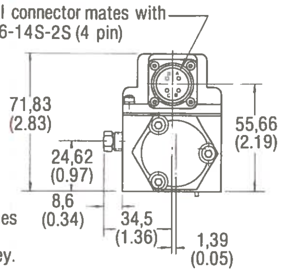

**Single:**
A+, B–
or
C+, D–




# SM4 installation dimensions; mm (inches)

## SM4-10/15

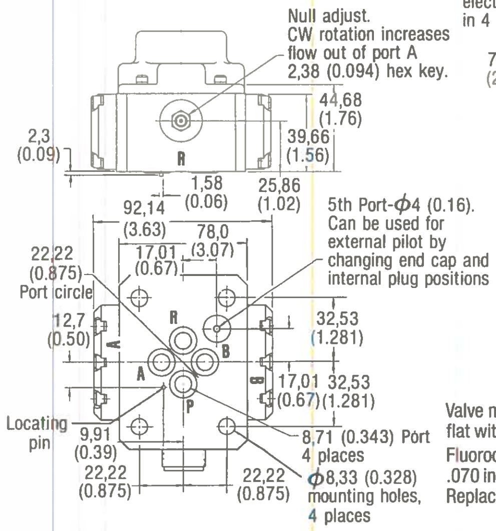


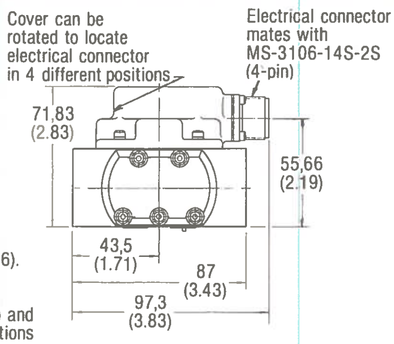




| Model | Dim A | Dim B |
|---|---|---|
| SM4-10 | 4,85 (.191) | 15,88 (.625) |
| SM4-15 | 7,92 (.312) | 23,80 (.937) |

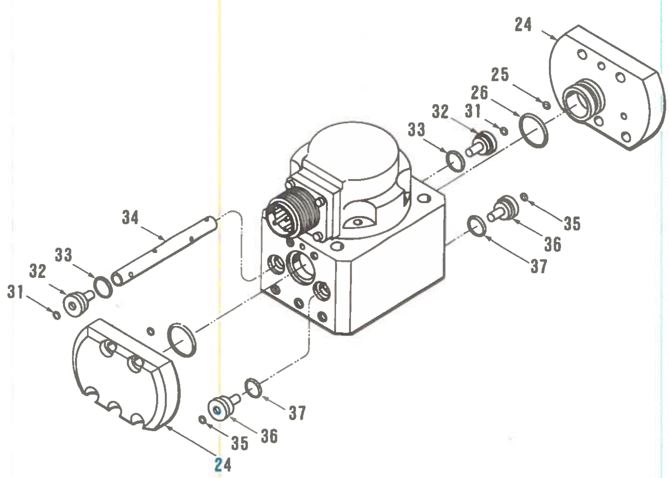
Valve mounting surface requires 32 microinch finish, flat within 0,025 (.001).
Fluorocarbon O-rings furnished for ports: AS568-010; .70 inch cross section and .239 inch inside diameter (SM4-10). AS568-013; .070 inch cross section and .426 inch inside diameter (SM4-15). Replacement seals are available in seal kits 920318 (SM4-10) and 920319 (SM4-15).

## SM4-20



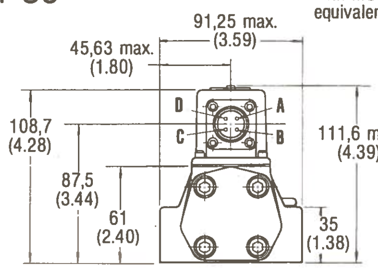

Valve mounting surface requires 32 microinch finish, flat within 0,025 (.001).
Fluorocarbon O-rings furnished for ports: AS568-013; .070 inch cross section and .426 inch inside diameter. Replacement seals are available in seal kit 920.320.

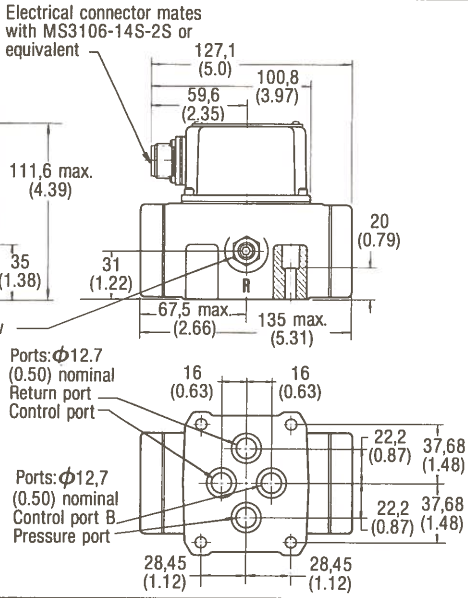



## Activation of optional 5th port (SM4-20) ▶ Procedure

1. Remove end caps (24) (will be relocated to opposite ends of valve in step 5).
2. Remove plug (36) and o-rings (35), (37).
3. Remove orifice (32), filter screen (34) and o-rings (31), (32). Install these items in place of items removed in step 2.
4. Install items removed in step 2 where orifice and filter screen were previously located. Reference step 3.
5. Install valve and caps on the opposite ends of valve from which they were removed. Reference step 1.
6. The valve's 5th port is now activated

## SM4-30

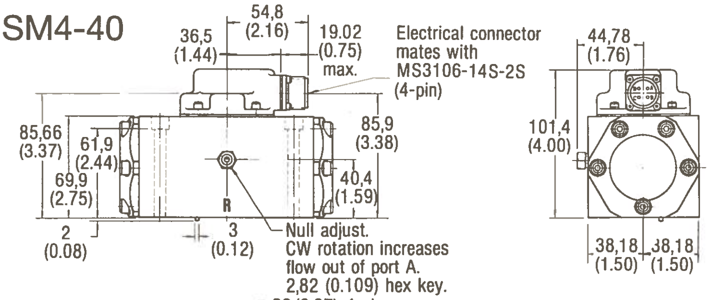


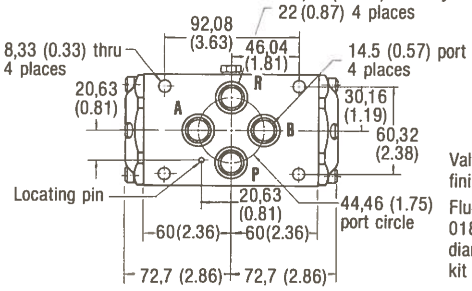




Valve mounting surface requires 32 microinch finish, flat within 0,025 (.001).

Fluorocarbon O-rings furnished for ports: AS568-016; .070 inch cross section and .614 inch inside diameter. Replacement seals are available in seal kit 855989.

## SM4-40




Valve mounting surface requires 63 microinch finish, flat within 0,05 (.002).

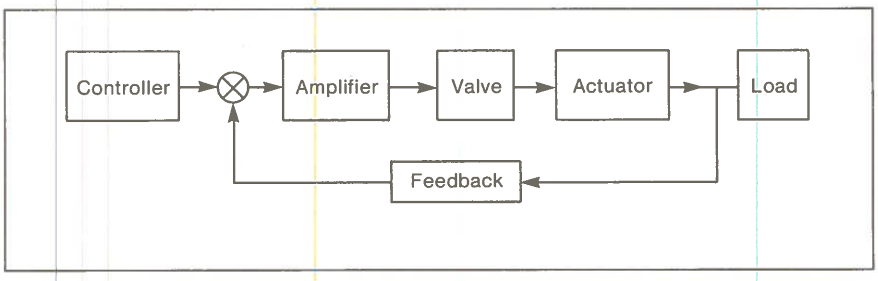
Fluorocarbon O-rings furnished for ports: AS568-018; .070 inch cross section and .739 inch inside diameter. Replacement seals are available in seal kit 920321.

# SM4 selection guidelines

## Sizing and application examples to simplify the selection of servo valves

Vickers servo calculations are valuable in initial sizing of system components, but full static and dynamic analyses should be made for each application. Please consult your Vickers representative.

## Principles of servo system analysis:




A servo system is a set of components that includes a servo valve, analog command source, power amplifier/summing junction, actuator, and feedback transducer.

In a closed loop servo system, the output of the actuator or load is continuously measured by a feedback transducer and compared to the command input signal.

Any errors are amplified and the resultant signal is applied to the servo valve to correct the actuator and load disturbance.

These devices have static and dynamic characteristics which can influence the selection of the proper servo valve.

In order to calculate the servo valve rated flow, it is important to consider the physical configuration of the actuator and load, total force requirements, maximum valocity, and acceleration/deceleration limits. Total force, F, includes all forces due to acceleration/deceleration, friction, and other external forces.

The following 12 application examples show typical configurations for differential (unequal area) cylinders, symmetrical (equal area) cylinders, and hydraulic motors. The force is considered for positive (resistive) and negative (overrunning) loads.

### Type of feedback

| | |
|---|---|
| Position | ± cm (± in) |
| Velocity | ± cm/s (± in/sec) or ± r/min (± rev/min) |
| Pressure | ± bar (psi) |
| Force | ± daN (lbf) |

# Application examples of hydraulic cylinders and motors with positive and negative load configurations

1.0 Extending differential cylinder with a positive load.

1.1 Retracting differential cylinder with a positive load.

2.0 Extending differential cylinder with a negative load.

2.1 Retracting differential cylinder with a negative load.

3.0 Extending differential cylinder on an inclined plane with a positive load.

3.1 Retracting differential cylinder on an inclined plane with a positive load.

4.0 Extending differential cylinder on an inclined plane with a negative load.

4.1 Retracting differential cylinder on an inclined plane with a negative load.

5.0 Extend/retract symmetrical cylinder with a positive load.

5.1 Extend/retract symmetrical cylinder with a negative load.

6.0 Rotate a hydraulic motor with a positive load.

6.1 Rotate a hydraulic motor with a negative load.

## Application notes:

1. If extend and retract load velocity requirements are the same, then select the servo valve rated flow based on the retract example.
2. If the calculated load pressure is more than the supply pressure, the load may not retract.
3. If the calculated load pressure is a negative value, then cavitation may occur.
4. If necessary, change the cylinder or motor size, supply pressure, and/or velocity requirements.
5. For all examples, calculate the servo valve rated flow based on the given parameters and then optimize the system variables by recalculation as desired.

## Given (or calculated) parameters for cylinder application examples

The ideal electrohydraulic cylinder provides hydraulic force proportional to servo valve differential pressure, and velocity proportional to servo valve control flow.

| Parameter or nomenclature | Calculation or symbol | Metric units | English units | Conversion |
|---|---|---|---|---|
| Acceleration (or deceleration) | $a = \frac{v_{MAX}}{T_a}$ | $\frac{cm}{s^2}$ | $\frac{in}{sec^2}$ | $2.54 \frac{cm}{s^2} / \frac{in}{sec^2}$ |
| Area, cap end | $A_1 = \frac{\pi D_P^2}{4}$ | $cm^2$ | $in^2$ | |
| Area, rod end | $A_2 = \frac{\pi (D_P^2 - D_R^2)}{4}$ | $cm^2$ | $in^2$ | $6.45\ cm^2/in^2$ |
| Area ratio | $R = \frac{A_1}{A_2}$ | | | |
| Diameter, piston | $D_P$ | cm | in | 2.54 cm/in |
| Diameter, rod | $D_R$ | cm | in | |
| Force, total required | $F = F_a + F_E + F_C + F_S$ | daN | lbf | 0.445 daN/lbf |
| Force, acceleration | $F_a = Ma$ | | | |
| Force, additive due to external disturbances | $F_E$ | | | |
| Force, load friction<br>$F_C = \mu W_L$ for horizontal plane<br>$F_C = \mu W_L \cos \theta$ for inclined plane<br>where $\mu$ = coefficient of friction with typical values of 0.1 to 0.3<br>$\theta$ = angle of incline in degrees | | | | |
| Force, maximum cylinder | $F_{MAX} = A_1 \cdot P_S$ | | | |
| Force, seal friction | $F_S = 0.1\ F_{MAX}$<br>or use values from the applicable cylinder catalog | | | |
| Load flow | $Q_L = 0{,}06A \cdot v_{MAX}$<br>when $A = cm^2$<br>$v_{MAX} = cm/sec$<br>$Q_L = \frac{A \cdot v_{MAX}}{3.85}$<br>when $A = in^2$<br>$v_{MAX} = in/sec$ | l/min | USgpm | $\frac{3.78\ l/min}{USgpm}$ |
| Load weight | $W_L$ | daN | lbf | 0.445 daN/lbf |
| Mass, total | $M = \frac{W_L}{g} + M_P$<br>where<br>$g = 1000\ cm/sec^2$<br>or<br>$g = 386\ in/sec^2$ | kg $\left(\frac{daN\ sec^2}{cm}\right)$ | lb $\left(\frac{lbf\ sec^2}{in}\right)$ | 0.454 kg/lb |
| Mass, piston | $M_P$ = values from applicable cylinder catalog | kg | lb | |

| Parameter or nomenclature | Calculation or symbol | Metric units | English units | Conversion |
|---|---|---|---|---|
| Pressure, cap end<br>rod end<br>supply<br>return (tank) | $P_1$ = calculated for each example<br>$P_2$ = calculated for each example<br>$P_S$ = based on cylinder or power unit size<br>$P_T$ = dependent on return line restrictions | bar | psi | 0.070 bar/psi |
| Stroke, cylinder | S | cm | in | 2.54 cm/in |
| Time, acceleration<br>deceleration<br>total limit | $t_a$<br>$t_d$<br>$t_l$ | sec | sec | |
| Velocity, maximum cylinder | $v_{MAX} = \frac{S}{(t_l - t_a)}$<br>where $t_a = t_d$ | $\frac{cm}{sec}$ | $\frac{in}{sec}$ | $2.54\ \frac{cm}{sec} \Big/ \frac{in}{sec}$ |

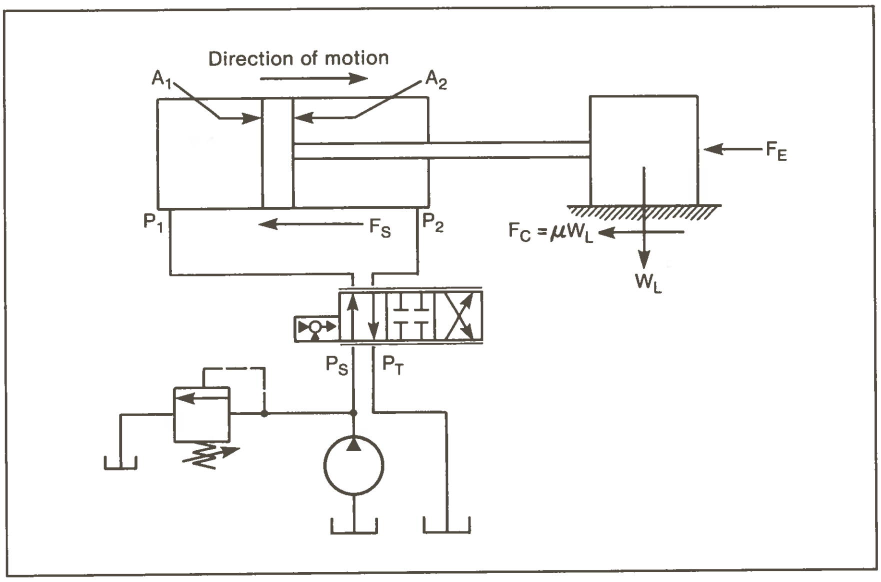
## Given (or calculated) parameters for hydraulic motor application examples

The ideal electrohydraulic motor provides torque proportional to servo valve differential pressure, and velocity (speed) proportional to servovalve control flow.

| Parameter or nomenclature | Calculation or symbol | Metric units | English units | Conversion |
|---|---|---|---|---|
| Acceleration, angular (or deceleration) | $a = \frac{\omega_M}{t_a}$ | $\frac{radians}{sec^2}$ | $\frac{radians}{sec^2}$ | |
| Displacement (motor) | $D_M$ | $\frac{cm^3}{r}$ | $\frac{in^3}{rev}$ | $\frac{16.4\ cm^3/r}{in^3/rev}$ |
| Inertia, total applied.<br>Inertia, load<br>Inertia, motor | $I = I_L + I_M$<br>$I_L$<br>$I_m = .005\ I_L$ to $.02\ I_L$ or use values from the applicable motor catalog | Nm-sec$^2$ | lbfin-sec$^2$ | $\frac{0.113\ Nm\text{-}sec^2}{lbfin\text{-}sec^2}$ |
| Load flow (motor) | $Q_{ML} = 0{,}01\ (\omega_M)\ D_M$<br>when $\omega_M$ = radians/sec<br>$D_M$ = cm$^3$/rev<br>$Q_{ML} = 0.04\ (\omega_M)\ D_M$<br>when $\omega_M$ = radians/sec<br>$D_M$ = in$^3$/rev | l/min | USgpm | $\frac{3.78\ l/min}{USgpm}$ |
| Pressure, inlet to motor<br>Pressure, outlet from motor<br>Pressure, supply<br>Pressure, tank (return) | $P_1$ = calculated for each example<br>$P_2$ = calculated for each example<br>$P_S$ = based on load torque required<br>$P_T$ = dependent on motor P required | bar | psi | $\frac{0.070\ bar}{psi}$ |
| Rotation, motor<br>Speed (velocity), maximum motor | $\theta_M$<br>$\omega_M = \frac{\theta_M}{t_l}$ | radians<br>$\frac{radians}{sec}$ | radians<br>$\frac{radians}{sec}$ | |
| Time, acceleration<br>deceleration<br>total limit | $t_a$<br>$t_d$<br>$t_l$ | sec<br>sec<br>sec | sec<br>sec<br>sec | |
| Torque, total required<br>Torque, damping<br>Torque, load | $T = \alpha I + T_L + T_D$<br>$T_D$ = use values from applicable motor catalog or estimate $T_D = 0.10\ T_L$ to $0.15\ T_L$<br>$T_L$ | Nm | lb fin | $\frac{0.113\ Nm}{lb\ fin}$ |

# Application example 1.0

## Differential cylinder extending with a positive load.




## Configuration 1.0:

| | |
|---|---|
| $F = Ma + F_C + F_E + F_S$ | daN (lbf) |

Using given parameters, find $P_1$ and $P_2$.

| | |
|---|---|
| $P_1 = \dfrac{P_S A_2 + R^2 (F + P_T A_2)}{A_2 (1 + R^3)}$ | bar (psi) |

| | |
|---|---|
| $P_2 = P_T + \dfrac{P_S - P_1}{R^2}$ | bar (psi) |

Check cylinder sizing and calculate rated flow, $Q_R$, dependent on load pressure $P_1$.

| | |
|---|---|
| $Q_L = 0{,}06\,(A_1)\,v_{MAX}$ | l/min |

| | |
|---|---|
| $Q_L = \dfrac{(A_1)\,v_{MAX}}{3.85}$ | USgpm |

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{35}{P_S - P_1}}$ | l/min |

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{500}{P_S - P_1}}$ | USgpm |

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 1.0:

in Metric units

$F$ = 4450 daN
$P_S$ = 210 bar
$P_T$ = 5,25 bar
$A_1$ = 53,5 cm$^2$
$A_2$ = 38,1 cm$^2$
$R$ = 1,4
$v_{MAX}$ = 30 cm/s

## Calculations 1.0:

in Metric units

$$P_1 = \frac{210\,(38{,}1) + 1{,}4^2\,(4450 + 5{,}25\,[38{,}1])}{38{,}1\,(1 + 1{,}4^3)} = 120$$

$$\boxed{P_1 = 120 \text{ bar}}$$

$$P_2 = 5{,}25 + \frac{210 - 120}{1{,}4^2} = 52$$

$$\boxed{P_2 = 52 \text{ bar}}$$

$$Q_L = 0{,}06\,(53{,}5)\,30 = 96$$

$$\boxed{Q_L = 96 \text{ l/min}}$$

$$Q_R = 96 \sqrt{\frac{35}{210 - 120}} = 60$$

$$\boxed{Q_R = 60 \text{ l/min}}$$

## Given parameters 1.0:

in English units

$F$ = 10,000 lbf
$P_S$ = 3,000 psi
$P_T$ = 75 psi
$A_1$ = 8.3 in$^2$
$A_2$ = 5.9 in$^2$
$R$ = 1.4
$v_{MAX}$ = 12 in/sec

## Calculations 1.0:

in English units

$$P_1 = \frac{3000\,(5.9) + 1.4^2\,(10{,}000 + 75\,[5.9])}{5.9\,(1 + 1.4^3)} = 1727$$

$$\boxed{P_1 = 1727 \text{ psi}}$$

$$P_2 = 75 + \frac{3000 - 1727}{1.4^2} = 724$$

$$\boxed{P_2 = 724 \text{ psi}}$$

$$Q_L = \frac{(8.3)\,12}{3.85} = 26$$

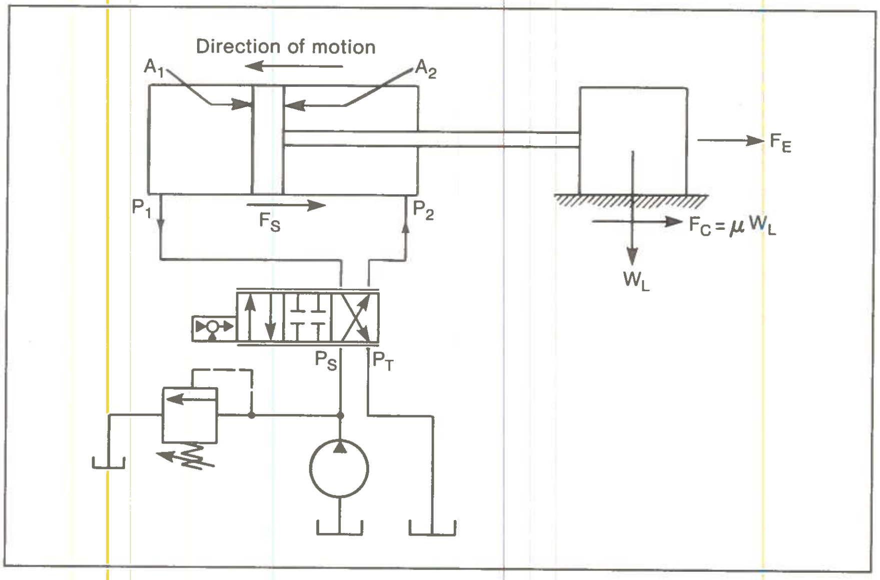
$$\boxed{Q_L = 26 \text{ USgpm}}$$

$$Q_R = 26 \sqrt{\frac{500}{3000 - 1727}} = 16$$

$$\boxed{Q_R = 16 \text{ USgpm}}$$

# Application example 1.1

## Differential cylinder retracting with a positive load.




### Configuration 1.1:

| | |
|---|---|
| $F = Ma + F_C + F_E + F_S$ | daN (lbf) |

Using given parameters, find $P_2$ and $P_1$.

| | |
|---|---|
| $P_2 = \dfrac{P_S A_2 R^3 + (F + P_T A_2 R)}{A_2 (1 + R^3)}$ | bar (psi) |

| | |
|---|---|
| $P_1 = P_T + (P_S - P_2) R^2$ | bar (psi) |

Check cylinder sizing and calculate rated flow, $Q_R$, dependent on load pressure $P_2$.

| | |
|---|---|
| $Q_L = 0{,}06\,(A_2)\,v_{MAX}$ | l/min |

| | |
|---|---|
| $Q_L = \dfrac{(A_2)\,v_{MAX}}{3.85}$ | USgpm |

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{35}{P_S - P_2}}$ | l/min |

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{500}{P_S - P_2}}$ | USgpm |

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

### Given parameters 1.1:

in Metric units

$F = 4450$ daN
$P_S = 210$ bar
$P_T = 5{,}25$ bar
$A_1 = 53{,}5\ cm^2$
$A_2 = 38{,}1\ cm^2$
$R = 1{,}4$
$v_{MAX} = 30$ cm/s

### Calculations 1.1:

in Metric units

$$P_2 = \frac{210\,(38{,}1)\,1{,}4^3 + 4450 + 5{,}25\,(38{,}1)\,1{,}4}{38{,}1\,(1 + 1{,}4^3)} = 187$$

$\boxed{P_2 = 187 \text{ bar}}$

$P_1 = 5{,}25 + (210 - 187)\,1{,}4^2 = 52$

$\boxed{P_1 = 52 \text{ bar}}$

$Q_L = 0{,}06\,(38{,}1)\,30 = 69$

$\boxed{Q_L = 69 \text{ l/min}}$

$$Q_R = 69 \sqrt{\frac{35}{210 - 187}} = 84$$

$\boxed{Q_R = 84 \text{ l/min}}$

### Given parameters 1.1:

in English units

$F = 10{,}000$ lbf
$P_S = 3{,}000$ psi
$P_T = 75$ psi
$A_1 = 8.3\ in^2$
$A_2 = 5.9\ in^2$
$R = 1.4$
$v_{MAX} = 12$ in/sec

### Calculations 1.1:

in English units

$$P_2 = \frac{3000\,(5.9)\,1.4^3 + (10{,}000 + 75\,[5.9]\,[1.4])}{5.9\,(1 + 1.4^3)} = 2678$$

$\boxed{P_2 = 2678 \text{ psi}}$

$P_1 = 75 + (3000 - 2678)\,1.4^2 = 706$

$\boxed{P_1 = 706 \text{ psi}}$

$$Q_L = \frac{(5.9)\,12}{3.85} = 18$$

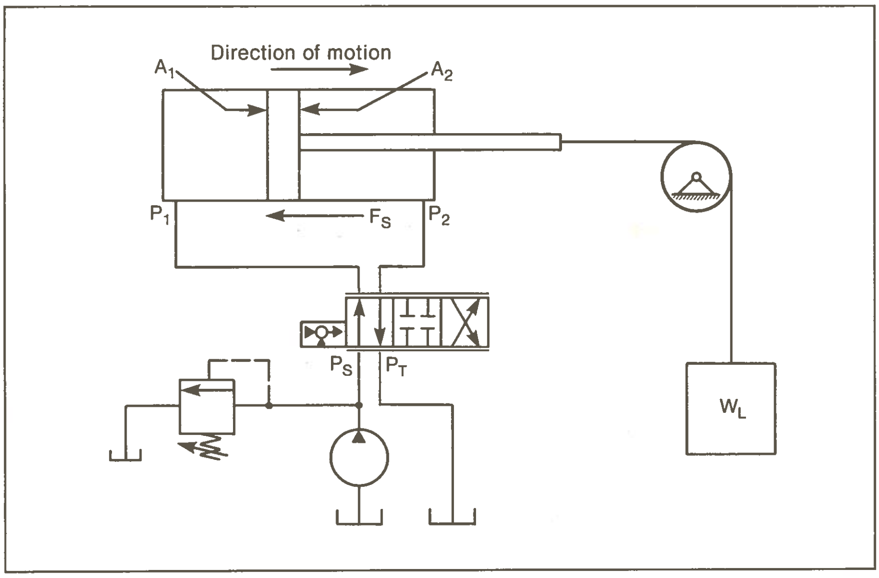
$\boxed{Q_L = 18 \text{ USgpm}}$

$$Q_R = 18 \sqrt{\frac{500}{3000 - 2678}} = 22$$

$\boxed{Q_R = 22 \text{ USgpm}}$

# Application example 2.0

## Differential cylinder extending with a negative load.




## Configuration 2.0:

| | |
|---|---|
| $F = Ma + F_S - W_L$ | daN (lbf) |

Using given parameters, find $P_1$ and $P_2$.

| | |
|---|---|
| $P_1 = \dfrac{P_S A_2 + R^2 (F + P_T A_2)}{A_2 (1 + R^3)}$ | bar (psi) |

| | |
|---|---|
| $P_2 = P_T + \dfrac{P_S - P_1}{R^2}$ | bar (psi) |

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on load pressure $P_1$.

| | |
|---|---|
| $Q_L = 0{,}06\,(A_1)\,v_{MAX}$ | l/min |

| | |
|---|---|
| $Q_L = \dfrac{(A_1)\,v_{MAX}}{3.85}$ | USgpm |

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{35}{P_S - P_1}}$ | l/min |

or

| | |
|---|---|
| $Q_R = Q_L \sqrt{\dfrac{500}{P_S - P_1}}$ | USgpm |

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 2.0:

in Metric units

$F = -2225$ daN
$P_S = 175$ bar
$P_T = 0$ bar
$A_1 = 81{,}3\ cm^2$
$A_2 = 61{,}3\ cm^2$
$R = 1{,}3$
$v_{MAX} = 12{,}7$ cm/s

## Calculations 2.0:

in Metric units

$$P_1 = \frac{175\,(61{,}3) + 1{,}3^2\,(-2225 + 0\,[61{,}3])}{61{,}3\,(1 + 1{,}3^3)} = 36$$

$\boxed{P_1 = 36 \text{ bar}}$

$$P_2 = 0 + \frac{175 - 36}{1{,}3^2} = 82$$

$\boxed{P_2 = 82 \text{ bar}}$

$Q_L = 0{,}06\,(81{,}3)\,12{,}7 = 62$

$\boxed{Q_L = 62 \text{ l/min}}$

$$Q_R = 62 \sqrt{\frac{35}{175 - 36}} = 31$$

$\boxed{Q_R = 31 \text{ l/min}}$

## Given parameters 2.0:

in English units

$F = -5{,}000$ lbf
$P_S = 2{,}500$ psi
$P_T = 0$ psi
$A_1 = 12.6\ in^2$
$A_2 = 9.5\ in^2$
$R = 1.3$
$v_{MAX} = 5$ in/sec

## Calculations 2.0:

in English units

$$P_1 = \frac{2500\,(9.5) + 1.3^2\,(-5000 + 0\,[9.5])}{9.5\,(1 + 1.3^3)} = 503$$

$\boxed{P_1 = 503 \text{ psi}}$

$$P_2 = 0 + \frac{2500 - 503}{1.3^2} = 1181$$

$\boxed{P_2 = 1181 \text{ psi}}$

$$Q_L = \frac{(12.6)\,5}{3.85} = 16$$

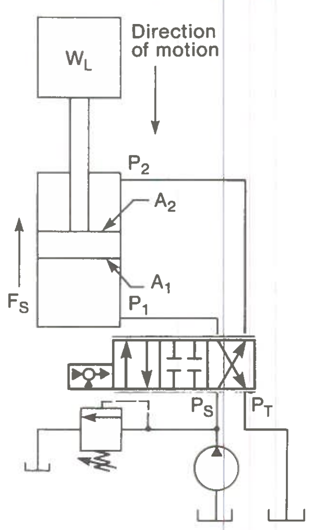
$\boxed{Q_L = 16 \text{ USgpm}}$

$$Q_R = 16 \sqrt{\frac{500}{2500 - 503}} = 8.0$$

$\boxed{Q_R = 8.0 \text{ USgpm}}$

# Application example 2.1

## Differential cylinder retracting with a negative load.




## Configuration 2.1:

$$F = Ma + F_S - W_L \qquad \text{daN (lbf)}$$

Using given parameters, find $P_2$ and $P_1$.

$$P_2 = \frac{P_S A_2 R^3 + (F + P_T A_2 R)}{A_2 (1 + R^3)} \quad \text{bar (psi)}$$

$$P_1 = P_T + (P_S - P_2) R^2 \qquad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on cap end pressure $P_2$.

$$Q_L = 0{,}06\,(A_2)\,v_{MAX} \qquad \text{l/min}$$

$$Q_L = \frac{(A_2)\,v_{MAX}}{3.85} \qquad \text{USgpm}$$

$$Q_R = Q_L \sqrt{\frac{35}{P_S - P_2}} \qquad \text{l/min}$$

or

$$Q_R = Q_L \sqrt{\frac{500}{P_S - P_2}} \qquad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 2.1:

in Metric units

$F$ = −4450 daN
$P_S$ = 210 bar
$P_T$ = 0 bar
$A_1$ = 81,3 $cm^2$
$A_2$ = 61,3 $cm^2$
$R$ = 1,3
$v_{MAX}$ = 25,4 cm/s

## Calculations 2.1:

in Metric units

$$P_2 = \frac{210\,(61{,}3)\,1{,}3^3 - 4450 + 0\,(61{,}3)\,1{,}3}{61{,}3\,(1 + 1{,}3^3)} = 122$$

$$\boxed{P_2 = 122 \text{ bar}}$$

$$P_1 = 0 + (210 - 122)\,1{,}3^2$$

$$\boxed{P_1 = 149 \text{ bar}}$$

$$Q_L = 0{,}06\,(61{,}3)\,25{,}4 = 93$$

$$\boxed{Q_L = 93 \text{ l/min}}$$

$$Q_R = 93 \sqrt{\frac{35}{210 - 122}} = 59$$

$$\boxed{Q_R = 59 \text{ l/min}}$$

## Given parameters 2.1:

in English units

$F$ = −10,000 lbf
$P_S$ = 3,000 psi
$P_T$ = 0 psi
$A_1$ = 12.6 $in^2$
$A_2$ = 9.5 $in^2$
$R$ =1.3
$v_{MAX}$ = 10 in/sec

## Calculations 2.1:

in English units

$$P_2 = \frac{3000\,(9.5)\,1.3^3 + (-10{,}000 + 0\,[9.5]\,1.3)}{9.5\,(1 + 1.3^3)} = 1734$$

$$\boxed{P_2 = 1734 \text{ psi}}$$

$$P_1 = 0 + (3000 - 1734)\,1.3^2 = 2140$$

$$\boxed{P_1 = 2140 \text{ psi}}$$

$$Q_L = \frac{(9.5)\,10}{3.85} = 25$$

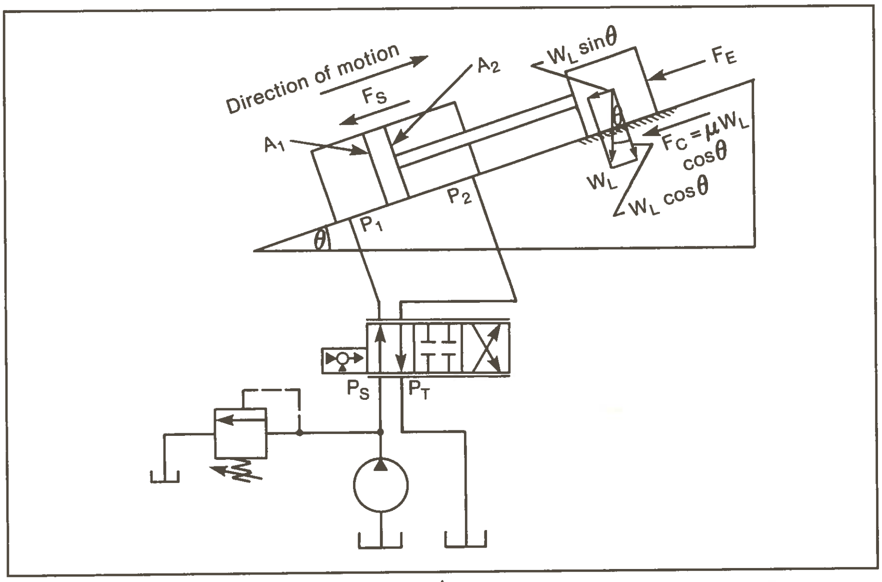
$$\boxed{Q_L = 25 \text{ USgpm}}$$

$$Q_R = 25 \sqrt{\frac{500}{3000 - 1734}} = 16$$

$$\boxed{Q_R = 16 \text{ USgpm}}$$

# Application example 3.0

## Differential cylinder extending on an inclined plane with a positive load.




### Configuration 3.0:

$$\boxed{F = Ma + F_E + F_S + W_L(\mu \cos\theta + \sin\theta)\ \text{daN (lbf)}}$$

Using given parameters, find $P_1$ and $P_2$.

$$\boxed{P_1 = \frac{P_S A_2 + R^2(F + P_T A_2)}{A_2(1 + R^3)} \quad \text{bar (psi)}}$$

$$\boxed{P_2 = P_T + \frac{P_S - P_1}{R^2} \quad \text{bar (psi)}}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on cap end pressure $P_1$.

$$\boxed{Q_L = 0{,}06\,(A_1)\,v_{MAX} \quad \text{l/min}}$$

$$\boxed{Q_L = \frac{(A_1)\,v_{MAX}}{3.85} \quad \text{USgpm}}$$

$$\boxed{Q_R = Q_L\sqrt{\frac{35}{P_S - P_1}} \quad \text{l/min}}$$

or

$$\boxed{Q_R = Q_L\sqrt{\frac{500}{P_S - P_1}} \quad \text{USgpm}}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

### Given parameters 3.0:

in Metric units

| | | |
|---|---|---|
| $F$ | = | 2225 daN |
| $P_S$ | = | 140 bar |
| $P_T$ | = | 3,5 bar |
| $A_1$ | = | 31,6 $cm^2$ |
| $A_2$ | = | 19,9 $cm^2$ |
| $R$ | = | 1,6 |
| $v_{MAX}$ | = | 12,7 cm/s |

### Calculations 3.0:

in Metric units

$$P_1 = \frac{140\,(19{,}9) + 1{,}6^2\,(2225 + 3{,}5\,[19{,}9])}{19{,}9\,(1 + 1{,}6^3)} = 85$$

$$\boxed{P_1 = 85 \text{ bar}}$$

$$P_2 = 35 + \frac{140 - 85}{1{,}6^2} = 25$$

$$\boxed{P_2 = 25 \text{ bar}}$$

$$Q_L = 0{,}06\,(31{,}6)\,12{,}7 = 24$$

$$\boxed{Q_L = 24 \text{ l/min}}$$

$$Q_R = 24\sqrt{\frac{35}{140 - 85}} = 19$$

$$\boxed{Q_R = 19 \text{ l/min}}$$

### Given parameters 3.0:

in English units

| | | |
|---|---|---|
| $F$ | = | 5,000 lbf |
| $P_S$ | = | 2,000 psi |
| $P_T$ | = | 50 psi |
| $A_1$ | = | 4.9 $in^2$ |
| $A_2$ | = | 3.1 $in^2$ |
| $R$ | = | 1.6 |
| $v_{MAX}$ | = | 5 in/sec |

### Calculations 3.0:

in English units

$$P_1 = \frac{2000\,(3.1) + 1.6^2\,(5{,}000 + 50\,[3.1])}{3.1\,(1 + 1.6^3)} = 1228$$

$$\boxed{P_1 = 1228 \text{ psi}}$$

$$P_2 = 50 + \frac{2000 - 1228}{1.6^2} = 352$$

$$\boxed{P_2 = 352 \text{ psi}}$$

$$Q_L = \frac{(4.9)\,5}{3.85} = 6.4$$

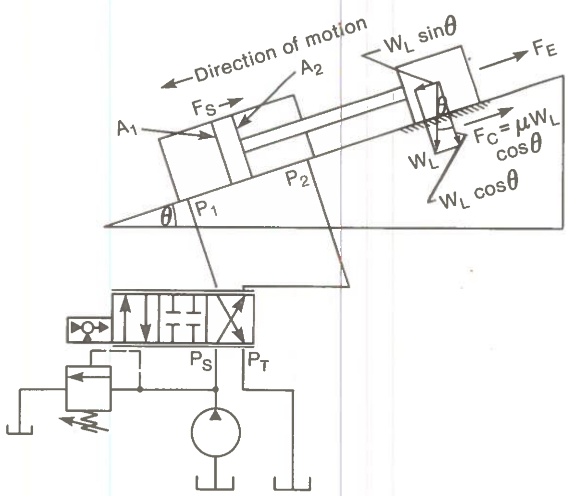
$$\boxed{Q_L = 6.4 \text{ USgpm}}$$

$$Q_R = 6.4\sqrt{\frac{500}{2000 - 1228}} = 5.2$$

$$\boxed{Q_R = 5.2 \text{ USgpm}}$$

# Application example 3.1

## Differential cylinder retracting on an inclined plane with a positive load.




### Configuration 3.1:

$$F = Ma + F_E + F_S + W_L (\mu \cos\theta + \sin\theta) \text{ daN (lbf)}$$

Using given parameters, find $P_2$ and $P_1$.

$$P_2 = \frac{P_S A_2 R^3 + (F + P_T A_2 R)}{A_2 (1 + R^3)} \text{ bar (psi)}$$

$$P_1 = P_T + (P_S - P_2) R^2 \quad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on rod end load pressure $P_2$.

$$Q_L = 0{,}06\,(A_2)\, v_{MAX} \quad \text{l/min}$$

or

$$Q_L = \frac{(A_2)\, v_{MAX}}{3.85} \quad \text{USgpm}$$

$$Q_R = Q_L \sqrt{\frac{35}{P_S - P_2}} \quad \text{l/min}$$

or

$$Q_R = Q_L \sqrt{\frac{500}{P_S - P_2}} \quad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

### Given parameters 3.1:
in Metric units

$F$ = 1780 daN
$P_S$ = 140 bar
$P_T$ = 3,5 bar
$A_1$ = 31,6 $cm^2$
$A_2$ = 19,9 $cm^2$
$R$ = 1,6
$v_{MAX}$ = 12,7 cm/s

### Calculations 3.1:
in Metric units

$$P_2 = \frac{140\,(19{,}9)\,1{,}6^3 + (1780 + 3{,}5\,[19{,}9]\,1{,}6)}{19{,}9\,(1 + 1{,}6^3)} = 131$$

$$\boxed{P_2 = 131 \text{ bar}}$$

$$P_1 = 35 + (140 - 131)\,1{,}6^2 = 26$$

$$\boxed{P_1 = 26 \text{ bar}}$$

$$Q_L = 0{,}06\,(19{,}9)\,12{,}7 = 15$$

$$\boxed{Q_L = 15 \text{ l/min}}$$

$$Q_R = 15 \sqrt{\frac{35}{140 - 131}} = 30$$

$$\boxed{Q_R = 30 \text{ l/min}}$$

### Given parameters 3.1:
in English units

$F$ = 4,000 lbf
$P_S$ = 2,000 psi
$P_T$ = 50 psi
$A_1$ = 4.9 $in^2$
$A_2$ = 3.1 $in^2$
$R$ = 1.6
$v_{MAX}$ = 5 in/sec

### Calculations 3.1:
in English units

$$P_2 = \frac{2000\,(3.1) + 1.6^3 + (4{,}000 + 50\,[3.1]\,[1.6])}{3.1\,(1 + 1.6^3)} = 1874$$

$$\boxed{P_2 = 1874 \text{ psi}}$$

$$P_1 = 50 + (2000 - 1874)\,1.6^2 = 373$$

$$\boxed{P_1 = 373 \text{ psi}}$$

$$Q_L = \frac{(3.1)\,5}{3.85} = 4.0$$

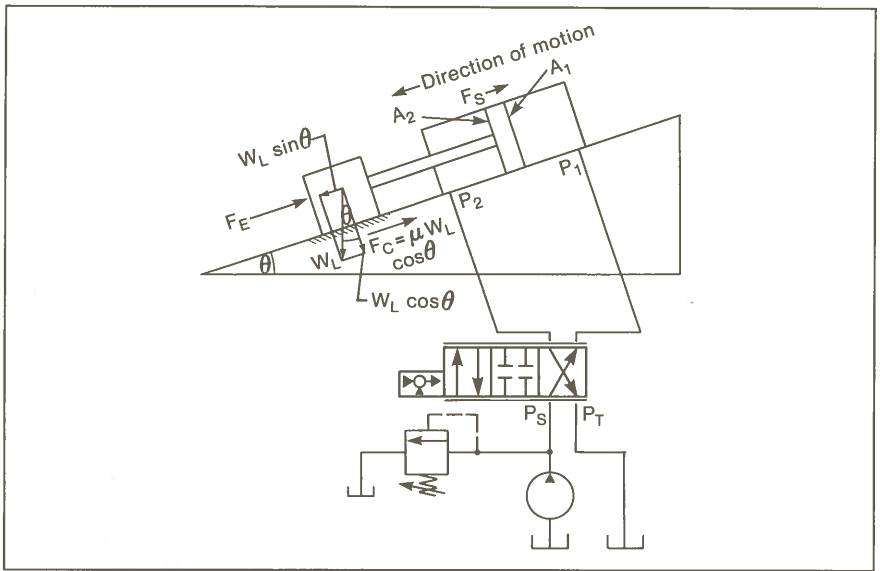
$$\boxed{Q_L = 4.0 \text{ USgpm}}$$

$$Q_R = 4 \sqrt{\frac{500}{2000 - 1638}} = 4.7$$

$$\boxed{Q_R = 4.7 \text{ USgpm}}$$

# Application example 4.0

## Differential cylinder extending on an inclined plane with a negative load.




## Configuration 4.0:

$F = Ma + F_E + F_S + W_L(\mu\cos\theta - \sin\theta)$ daN (lbf)

Using given parameters, find $P_1$ and $P_2$.

$$P_1 = \frac{P_S A_2 + R^2(F + P_T A_2)}{A_2(1 + R^3)} \quad \text{bar (psi)}$$

$$P_2 = P_T + \frac{P_S - P_1}{R^2} \quad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on cap end pressure $P_1$.

$$Q_L = 0{,}06\,(A_1)\,v_{MAX} \quad \text{l/min}$$

or

$$Q_L = \frac{(A_1)\,v_{MAX}}{3.85} \quad \text{USgpm}$$

$$Q_R = Q_L\sqrt{\frac{35}{P_S - P_1}} \quad \text{l/min}$$

or

$$Q_R = Q_L\sqrt{\frac{500}{P_S - P_1}} \quad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 4.0:
in Metric units

$F$ = −6675 daN
$P_S$ = 210 bar
$P_T$ = 0 bar
$A_1$ = 53,5 cm$^2$
$A_2$ = 38,1 cm$^2$
$R$ = 1,4
$v_{MAX}$ = 25,4 cm/s

## Calculations 4.0:
in Metric units

$$P_1 = \frac{210\,(38{,}1) + 1{,}4^2\,(-6675 + 0\,[38{,}1])}{38{,}1\,(1 + 1{,}4^3)} = -36$$

$P_1 = -36$ bar

## Caution:

Negative load will cause cylinder cavitation. Change given parameters by increasing cylinder size, system pressure, or decreasing the total force required.

choose; in Metric units

$A_1$ = 126 cm$^2$
$A_2$ = 106 cm$^2$
$R$ = 1,2

## Calculations 4.0:
in Metric units

$$P_1 = \frac{210\,(106) + 1{,}2^2\,(-6675 + 0\,[106])}{106\,(1 + 1{,}2^3)} = 44$$

$P_1 = 44$ bar

$$P_2 = \frac{210 - 44}{1{,}2^2} = 116$$

$P_2 = 116$ bar

$Q_L = 0{,}06\,(126)\,25{,}4 = 192$

$Q_L = 192$ l/min

$$Q_R = 192\sqrt{\frac{35}{210 - 44}} = 88$$

$Q_R = 88$ l/min

## Given parameters 4.0:
in English units

$F$ = −15,000 lbf
$P_S$ = 3,000 psi
$P_T$ = 0 psi
$A_1$ = 8.3 in$^2$
$A_2$ = 5.9 in$^2$
$R$ = 1.4
$v_{MAX}$ = 10 in/sec

## Calculations 4.0:
in English units

$$P_1 = \frac{3000\,(5.9) + 1.4^2\,(-15{,}000 + 0\,[5.9])}{5.9\,(1 + 1.4^3)} = -530$$

$P_1 = -530$ psi

## Caution:

Negative load will cause cylinder cavitation. Change given parameters by increasing cylinder size, system pressure, or decreasing the total force required.

choose; in English units

$A_1$ = 19.6 in$^2$
$A_2$ = 16.5 in$^2$
$R$ = 1.2

$$P_1 = \frac{3000\,(16.5) + 1.2^2\,(-15{,}000 + 0\,[16.5])}{16.5\,(1 + 1{,}2^3)} = 620$$

$P_1 = 620$ psi

$$P_2 = 0 + \frac{3000 - 620}{1.2^2} = 1653$$

$P_2 = 1653$ psi

$$Q_L = \frac{(19.6)\,10}{3.85} = 51$$

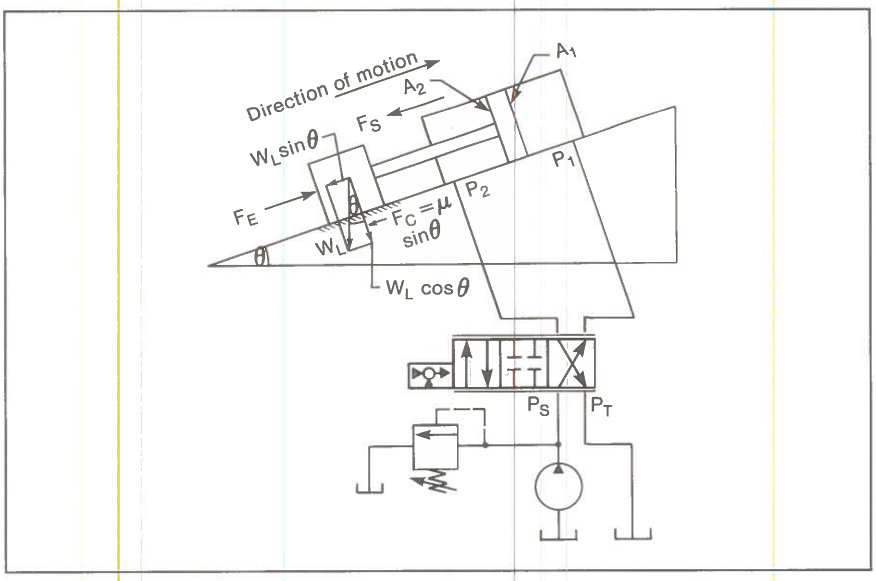
$Q_L = 51$ USgpm

$$Q_R = 51\sqrt{\frac{500}{3000 - 620}} = 23$$

$Q_R = 23$ USgpm

# Application example 4.1

Differential cylinder retracting on an inclined plane with a negative load.




## Configuration 4.1:

$$F = Ma + F_E + F_S + W_L(\mu\cos\theta - \sin\theta) \text{ daN (lbf)}$$

Using given parameters, find $P_2$ and $P_1$.

$$P_2 = \frac{P_S A_2 R^3 + (F + P_T A_2 R)}{A_2(1 + R^3)} \text{ bar (psi)}$$

$$P_1 = P_T + (P_S - P_2) R^2 \quad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on rod end pressure $P_2$.

$$Q_L = 0{,}06\,(A_2)\,v_{MAX} \quad \text{l/min}$$

or

$$Q_L = \frac{(A_2)\,v_{MAX}}{3.85} \quad \text{USgpm}$$

$$Q_R = Q_L \sqrt{\frac{35}{P_S - P_2}} \quad \text{l/min}$$

or

$$Q_R = Q_L \sqrt{\frac{500}{P_S - P_2}} \quad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 4.1:

in Metric units

| | | |
|---|---|---|
| F | = | −6675 daN |
| $P_S$ | = | 210 bar |
| $P_T$ | = | 0 bar |
| $A_1$ | = | 53,5 cm² |
| $A_2$ | = | 38,1 cm² |
| R | = | 1,4 |
| $v_{MAX}$ | = | 25,4 cm/s |

## Calculations 4.1:

in Metric units

$$P_2 = \frac{210\,(38{,}1)\,1{,}4^3 + (-6375 + 0\,[38{,}1]\,1{,}4)}{38{,}1\,(1 + 1{,}4^3)} = 107$$

$$\boxed{P_2 = 107 \text{ bar}}$$

$$P_1 = 0 + (210 - 107)\,1{,}4^2 = 202$$

$$\boxed{P_1 = 202 \text{ bar}}$$

$$Q_L = \frac{(38{,}1)\,25{,}4}{16{,}67} = 58$$

$$\boxed{Q_L = 58 \text{ l/min}}$$

$$Q_R = 58\sqrt{\frac{35}{210 - 107}} = 34$$

$$\boxed{Q_R = 34 \text{ l/min}}$$

## Given parameters 4.1:

in English units

| | | |
|---|---|---|
| F | = | −15,000 lbf |
| $P_S$ | = | 3,000 psi |
| $P_T$ | = | 0 psi |
| $A_1$ | = | 8.3 in² |
| $A_2$ | = | 5.9 in² |
| R | = | 1.4 |
| $v_{MAX}$ | = | 10 in/sec |

## Calculations 4.1:

in English units

$$P_2 = \frac{3000\,(5.9) + 1.4^3 + (-15{,}000 + 0\,[5.9]\,1.4)}{5.9\,(1 + 1.4^3)} = 1518$$

$$\boxed{P_2 = 1518 \text{ psi}}$$

$$P_1 = 0 + (3000 - 1518)\,1.4^2 = 2904$$

$$\boxed{P_1 = 2904 \text{ psi}}$$

$$Q_L = \frac{(5.9)\,10}{3.85} = 15$$

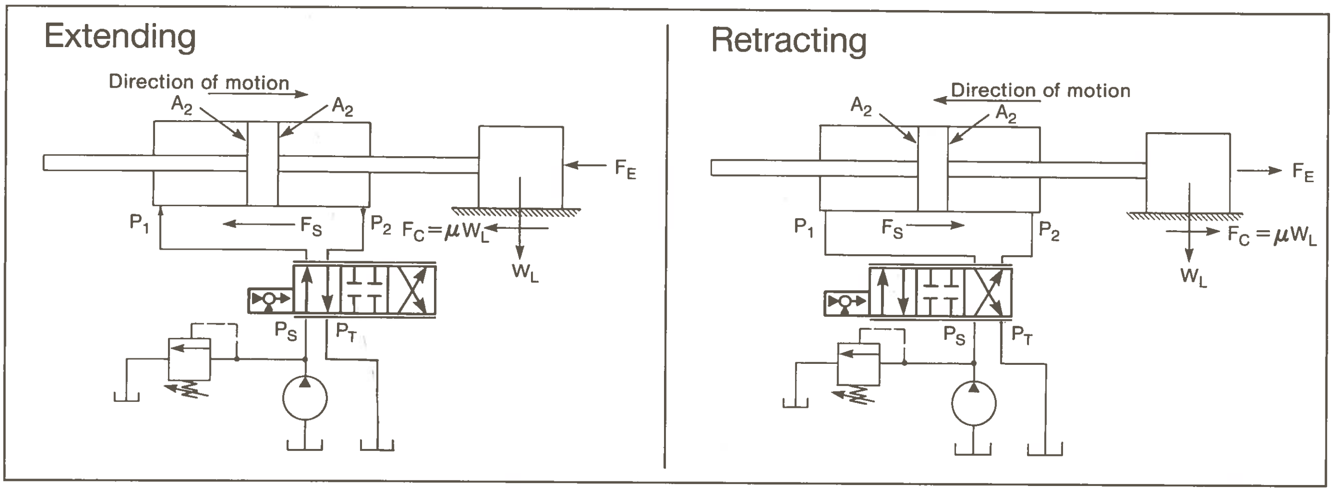
$$\boxed{Q_L = 15 \text{ USgpm}}$$

$$Q_R = 15\sqrt{\frac{500}{3000 - 1518}} = 8.7$$

$$\boxed{Q_R = 8.7 \text{ USgpm}}$$

# Application example 5.0

## Symmetrical cylinder with a positive load.




## Configuration 5.0:

| $F = Ma + F_C + F_E + F_S$ | daN (lbf) |
|---|---|

Using given parameters, find $P_1$.

$$P_1 = \frac{P_S A_2 + (F + P_T A_2)}{2\,A_2} \quad \text{bar (psi)}$$

$$P_2 = P_S - P_1 + P_T \quad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on pressure $P_1$.

$$Q_L = 0{,}06\,(A_2)\,v_{MAX} \quad \text{l/min}$$

or

$$Q_L = \frac{(A_2)\,v_{MAX}}{3.85} \quad \text{USgpm}$$

$$Q_R = Q_L \sqrt{\frac{35}{P_S - P_1}} \quad \text{l/min}$$

or

$$Q_R = Q_L \sqrt{\frac{500}{P_S - P_1}} \quad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 5.0:

in Metric units

$F$ = 4450 daN
$P_S$ = 175 bar
$P_T$ = 5,25 bar
$A_2$ = 38,1 cm$^2$
$v_{MAX}$ = 12,7 cm/s

## Calculations 5.0:

in Metric units

$$P_1 = \frac{175\,(38{,}1) + (4450 + 5{,}25\,[38{,}1])}{2\,(38{,}1)} = 149$$

$$\boxed{P_1 = 149 \text{ bar}}$$

$$P_2 = 175 - 149 + 5{,}25 = 32$$

$$\boxed{P_2 = 32 \text{ bar}}$$

$$Q_L = 0{,}66\,(38{,}1)\,12{,}7 = 29$$

$$\boxed{Q_L = 29 \text{ l/min}}$$

$$Q_R = 29 \sqrt{\frac{35}{175 - 149}} = 34$$

$$\boxed{Q_R = 34 \text{ l/min}}$$

## Given parameters 5.0:

in English units

$F$ = 10,000 lbf
$P_S$ = 2,500 psi
$P_T$ = 75 psi
$A_2$ = 5.9 in$^2$
$v_{MAX}$ = 5 in/sec

## Calculations 5.0:

in English units

$$P_1 = \frac{2500\,(5.9) + (10{,}000 + 75\,[5.9])}{2\,(5.9)} = 2134$$

$$\boxed{P_1 = 2134 \text{ psi}}$$

$$P_2 = 2500 - 2134 + 75 = 441$$

$$\boxed{P_2 = 441 \text{ psi}}$$

$$Q_L = \frac{(5.9)\,5}{3.85} = 7.6$$

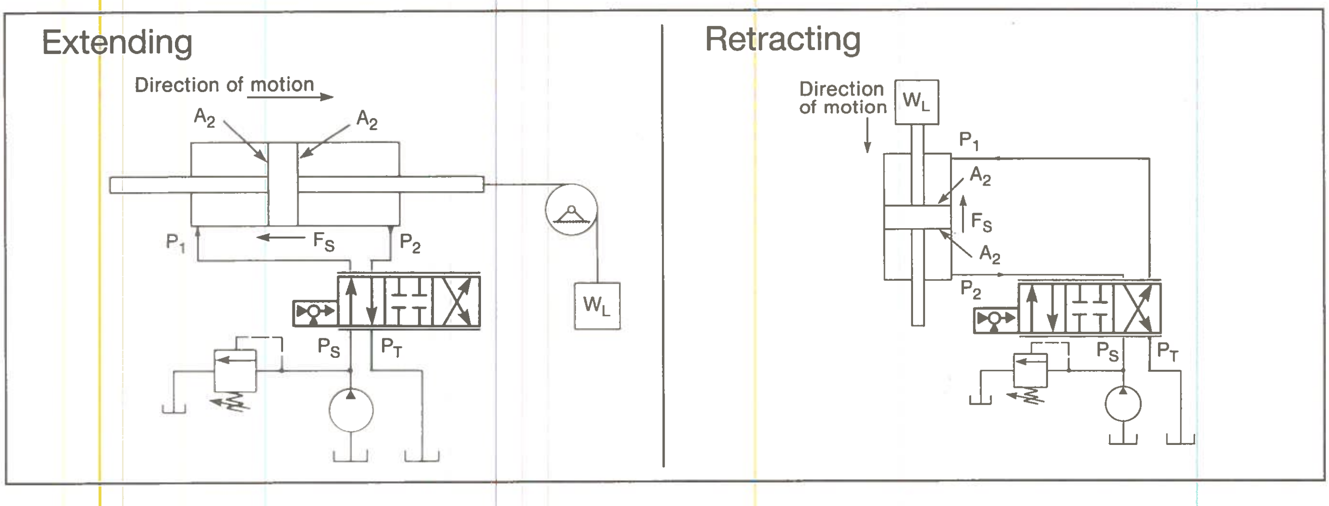
$$\boxed{Q_L = 7.6 \text{ USgpm}}$$

$$Q_R = 7.6 \sqrt{\frac{500}{2500 - 2134}} = 9.0$$

$$\boxed{Q_R = 9.0 \text{ USgpm}}$$

# Application example 5.1

## Symmetrical cylinder with a negative load.




## Configuration 5.1:

| |
|---|
| $F = Ma + F_S - W_L$ daN (lbf) |

Using given parameters, find $P_1$.

| |
|---|
| $P_1 = \dfrac{P_S A_2 + (F + P_T A_2)}{2\,A_2}$ bar (psi) |

| |
|---|
| $P_2 = P_S - P_1 + P_T$ bar (psi) |

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on pressure $P_1$.

| |
|---|
| $Q_L = 0{,}06\,(A_2)\,v_{MAX}$ l/min |

or

| |
|---|
| $Q_L = \dfrac{(A_2)\,v_{MAX}}{3.85}$ USgpm |

| |
|---|
| $Q_R = Q_L \sqrt{\dfrac{35}{P_S - P_1}}$ l/min |
| $Q_R = Q_L \sqrt{\dfrac{500}{P_S - P_1}}$ USgpm |

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 5.1:

in Metric units

$F = -4450$ daN
$P_S = 210$ bar
$P_T = 0$ bar
$A_2 = 60{,}6\ cm^2$
$v_{MAX} = 12{,}7$ cm/s

## Calculations 5.1:

in Metric units

$$P_1 = \frac{210\,(60{,}6) + (-4450 + 0\,[60{,}6])}{2\,(60{,}6)} = 68$$

| |
|---|
| $P_1 = 68$ bar |

$P_2 = 210 - 68 + 0 = 142$

| |
|---|
| $P_2 = 142$ bar |

$Q_L = 0{,}06\,(60{,}6)\,12{,}7 = 46$

| |
|---|
| $Q_L = 46$ l/min |

$$Q_R = 46 \sqrt{\frac{35}{210 - 68}} = 23$$

| |
|---|
| $Q_R = 23$ l/min |

## Given parameters 5.1:

in English units

$F = -10{,}000$ lbf
$P_S = 3{,}000$ psi
$P_T = 0$ psi
$A_2 = 9.4\ in^2$
$v_{MAX} = 5$ in/sec

## Calculations 5.1:

in English units

$$P_1 = \frac{3000\,(9.4) + (-10{,}000 + 0\,[9.4])}{2\,(9.4)} = 968$$

| |
|---|
| $P_1 = 968$ psi |

$P_2 = 3000 - 968 + 0 = 2032$

| |
|---|
| $P_1 = 2032$ psi |

$$Q_L = \frac{(9.4)\,5}{3.85} = 12$$

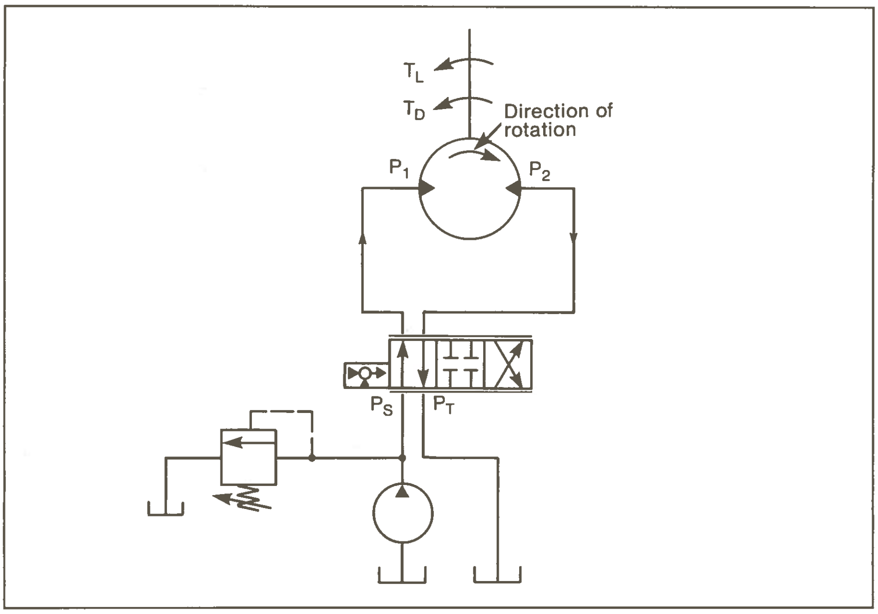
| |
|---|
| $Q_L = 12$ USgpm |

$$Q_R = 12 \sqrt{\frac{500}{3000 - 968}} = 6.0$$

| |
|---|
| $Q_R = 6.0$ USgpm |

# Application example 6.0

## Hydraulic motor with a positive load.




## Configuration 6.0:

$$T = \alpha \, I + T_D + T_L \qquad \text{Nm (lbfin)}$$

Using given parameters, find $P_1$ and $P_2$.

$$P_1 = \frac{P_S + P_T}{2} + \frac{10\,\pi T}{D_M} \qquad \text{bar}$$

$$P_1 = \frac{P_S + P_T}{2} + \frac{\pi T}{D_M} \qquad \text{psi}$$

$$P_2 = (P_S - P_1 + P_T) \qquad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on pressure $P_1$.

$$Q_{ML} = 0{,}01\,(\omega_M)\,D_M \qquad \text{l/min}$$

or

$$Q_{ML} = 0.04\,(\omega_M)\,D_M \qquad \text{USgpm}$$

$$Q_R = Q_{ML}\sqrt{\frac{35}{P_S - P_1}} \qquad \text{l/min}$$

or

$$Q_R = Q_{ML}\sqrt{\frac{500}{P_S - P_1}} \qquad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 6.0:

in Metric units

$T$ = 56,5 Nm
$P_S$ = 210 bar
$P_T$ = 0 bar
$D_M$ = 82 $cm^3$/r
$\omega_M$ = 10 rad/s

## Calculations 6.0:

in Metric units

$$P_1 = \frac{210 + 0}{2} + \frac{10\pi\,(56{,}5)}{82} = 127$$

$$\boxed{P_1 = 127 \text{ bar}}$$

$$P_2 = 210 - 127 + 0 = 83$$

$$\boxed{P_2 = 83 \text{ bar}}$$

$$Q_{ML} = 0{,}01\,(10)\,82 = 8{,}2$$

$$\boxed{Q_{ML} = 8{,}2 \text{ l/min}}$$

$$Q_R = 8{,}2\sqrt{\frac{35}{210 - 127}} = 5{,}3$$

$$\boxed{Q_R = 5{,}3 \text{ l/min}}$$

## Given parameters 6.0:

in English units

$T$ = 500 lbfin
$P_S$ = 3000 psi
$P_T$ = 0 psi
$D_M$ = 5 $in^3$/rev.
$\omega_M$ = 10 radians/sec

## Calculations 6.0:

in English units

$$P_1 = \frac{3000 + 0}{2} + \frac{\pi\,500}{5} = 1814$$

$$\boxed{P_1 = 1814 \text{ psi}}$$

$$P_2 = (3000 - 1814 + 0) = 1186$$

$$\boxed{P_2 = 1186 \text{ psi}}$$

$$Q_{ML} = 0.04\,(10)\,5 = 2.0$$

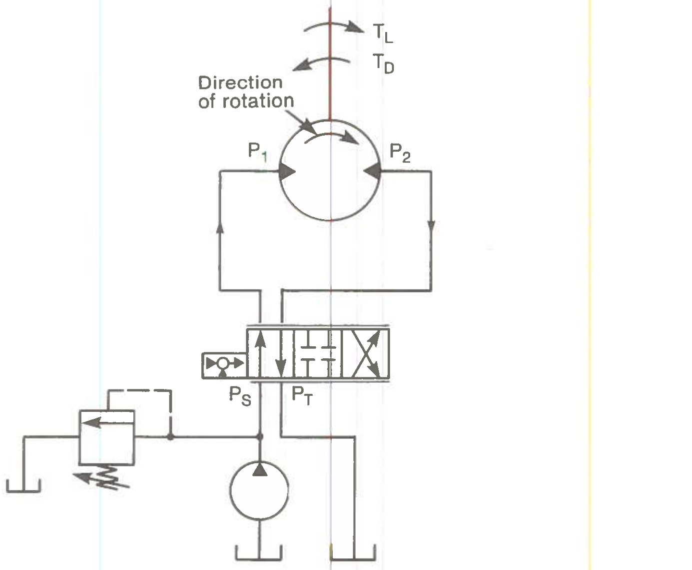
$$\boxed{Q_{ML} = 2.0 \text{ USgpm}}$$

$$Q_R = 2.0\sqrt{\frac{500}{3000 - 1814}} = 1.3$$

$$\boxed{Q_R = 1.3 \text{ USgpm}}$$

# Application example 6.1

## Hydraulic motor with a negative load.




## Configuration 6.1:

$$T = \alpha I - T_D + T_L \qquad \text{Nm (lbfin)}$$

Using given parameters, find $P_1$ and $P_2$.

$$P_1 = \frac{P_S + P_T}{2} + \frac{10\,\pi T}{D_M} \qquad \text{bar}$$

$$P_1 = \frac{P_S + P_T}{2} + \frac{\pi T}{D_M} \qquad \text{psi}$$

$$P_2 = (P_S - P_1 + P_T) \qquad \text{bar (psi)}$$

Check cylinder sizing and calculate servo valve rated flow, $Q_R$, dependent on pressure $P_1$.

$$Q_{ML} = 0{,}01\ (\omega_M)\ D_M \qquad \text{l/min}$$

or

$$Q_{ML} = 0.04\ (\omega_M)\ D_M \qquad \text{USgpm}$$

$$Q_R = Q_{ML}\sqrt{\frac{35}{P_S - P_1}} \qquad \text{l/min}$$

or

$$Q_R = Q_{ML}\sqrt{\frac{500}{P_S - P_1}} \qquad \text{USgpm}$$

Select a standard SM4 servo valve size equal to or greater than the calculated $Q_R$.

## Given parameters 6.1:

in Metric units

$T$ = −170 Nm
$P_S$ = 210 bar
$P_T$ = 0 bar
$D_M$ = 82 $cm^3$/r
$\omega_M$ = 10 rad/s

## Calculations 6.1:

in Metric units

$$P_1 = \frac{210 + 0}{2} + \frac{10\pi\,(-170)}{82} = 40$$

$$\boxed{P_1 = 40 \text{ bar}}$$

$$P_2 = 210 - 40 + 0 = 170$$

$$\boxed{P_2 = 170 \text{ bar}}$$

$$Q_{ML} = 0{,}01\ (10)\ 82 = 8{,}2$$

$$\boxed{Q_{ML} = 8{,}2 \text{ l/min}}$$

$$Q_R = 8{,}2\sqrt{\frac{35}{210 - 40}} = 3{,}6$$

$$\boxed{Q_R = 3{,}6 \text{ l/min}}$$

## Given parameters 6.1:

in English units

$T$ = −1500 lbfin
$P_S$ = 3000 psi
$P_T$ = 0 psi
$D_M$ = 5 $in^3$/rev.
$\omega_M$ = 10 radians/sec

## Calculations 6.1:

in English units

$$P_1 = \frac{3000 + 0}{2} + \frac{\pi\,(-1500)}{5} = 558$$

$$\boxed{P_1 = 558 \text{ psi}}$$

$$P_2 = (3000 - 558 + 0) = 2442$$

$$\boxed{P_2 = 2442 \text{ psi}}$$

$$Q_{ML} = 0.04\ (10)\ 5 = 2.0$$

$$\boxed{Q_{ML} = 2.0 \text{ USgpm}}$$

$$Q_R = 2.0\sqrt{\frac{500}{3000 - 558}} = 1.0$$

$$\boxed{Q_R = 1.0 \text{ USgpm}}$$

# Ordering information

## Specify the following requirements to ensure the proper model selection.

Using the data on catalog pages 18 to 25 and the servo valve application and sizing guidelines on pages 26 to 40, determine whether a standard or customized valve is needed for your application. After selecting the servo valve model and part number, choose the required accessory products using the charts following each valve size on pages 42 to 44.

### Model code for standard SM4 servo valves

SM4-**-(***)***-****/***-**

[1] [2] [3] [4]

[1] Valve size and port circle mounting interface

| Valve size | Port circle |
|---|---|
| 10 | 15,9 mm (0.625 in) |
| 15 | 23,9 mm (0.937 in) |
| 20 | 22,2 mm (0.875 in) |
| 30 | * Non-circular |
| 40 | 44,5 mm (1.750 in) |

* See page 25 for port configuration

[2] Rated flow at 70 bar (1000 psi) Δp (P-A-B-T)

| Code (USgpm) l/min | Available with SM4- 10 | 15 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| (1.0) 3,8 | ● | ● | ● | | |
| (2.5) 9 | ● | ● | ● | | |
| (5.0) 19 | ● | ● | ● | | |
| (7.5) 28 | ● | ● | ● | | |
| (10) 38 | ● | ● | ● | | |
| (12.5) 47 | | ● | ● | | |
| (15) 57 | | ● | ● | ● | |
| (20) 76 | | | ● | ● | ● |
| (25) 95 | | | | ● | ● |
| (30) 113 | | | | ● | ● |
| (35) 132 | | | | | ● |
| (40) 151 | | | | | ● |

[3] Coil resistance/rated current code (Ohms/mA) at 21°C (70°F)

| | |
|---|---|
| 200/15<br>80/40<br>30/100<br>20/100 | Standard options for SM4-10, 15, 20 and 40 sizes |
| 80/65 | For SM4-30 only |

[4] Design number

10 series for SM4-10, 15, 20 and 40.
20 series for SM4-30.
Subject to change.
Installation dimension unaltered for design numbers *0 to *9 inclusive

## Servo valves and accessories must be ordered separately.

### Example of an order for inch units

| Quantity | Model description | Part no. |
|---|---|---|
| 1 | SM4-20(10)38-200/15-10 valve | 689783 |
| 1 | Valve mounting bolt kit BK866687 | 866687 |
| 1 | SM4M-20-10 rear port subplate manifold | 682997 |
| 1 | Subplate manifold bolt kit BK855992 | 855992 |
| 1 | SM4FV-20-10 flushing valve | 682999 |
| 1 | Flushing valve bolt kit | 688701 |

### Example of an order for metric units

| Quantity | Model description | Part no. |
|---|---|---|
| 1 | SM4-20(10)38-200/15-10 valve | 689783 |
| 1 | Valve mounting bolt kit BK866690M | 866690M |
| 1 | SM4M-20-10M rear port subplate manifold | 866664 |
| 1 | Subplate manifold bolt kit BK855993M | 855993M |
| 1 | SM4FV-20-10 flushing valve | 682999 |
| 1 | Flushing valve bolt kit BK689630M | 68963M |

### Model code for customized versions of SM4 servo valves

a. From the standard code above, determine the designation of the servo valve nearest to the requirements.
b. Separately list and define the characteristics of all customized features for the application. Your Vickers representative will be pleased to assist.
c. After completion of any necessary design and development work, Vickers will assign an S-number suffix that will define the group of special features. The complete model designation will then be in the form of;

SM4-**-(***)***-****/***-**-S***

[5]

[5] Special features suffix

One unique suffix, e. g. S963, will denote a particular group of customized features such as:

Rated flow,
coil resistance/current,
spool % overlap/underlap,
electrical connector position,
5th port (pilot pressure) SM4-20 only,
high frequency response,
high pressure version.

Note: Customized models will affect price and delivery.

*Standard model and part numbers are listed on pages 42 to 44. Recommended selections are shown in bold print for your convenience.*

# Standard SM4-10 servo valves

| Model number | Part number |
|---|---|
| **SM4-10(1)3.8-80/40-10** | **855356** |
| **SM4-10(1)3.8-20/200-10** | **687982** |
| SM4-10(1)3.8-200/15-10 | 855352 |
| SM4-10(1)3.8-30/100-10 | 855357 |
| **SM4-10(2.5)9-80/40-10** | **689896** |
| **SM4-10(2.5)9-20/200-10** | **683582** |
| SM4-10(2.5)9-200/15-10 | 855353 |
| SM4-10(2.5)9-30/100-10 | 855358 |
| **SM4-10(5)19-80/40-10** | **689875** |
| **SM4-10(5)19-20/200-10** | **683005** |
| SM4-10(5)19-200/15-10 | 855354 |
| SM4-10(5)19-30/100-10 | 855359 |
| **SM4-10(7.5)28-80/40-10** | **514604** |
| **SM4-10(7.5)28-20/200-10** | **683585** |
| SM4-10(7.5)28-200/15-10 | 855355 |
| SM4-10(7.5)28-30/100-10 | 855360 |
| **SM4-10(10)38-80/40-10** | **855970** |
| **SM4-10(10)38-20/200-10** | **688727** |
| SM4-10(10)38-200/15-10 | 855969 |
| SM4-10(10)38-30/100-10 | 855971 |

Recommended selections shown in bold print.

# SM4-10 accessories

| Description | Model number | Part number |
|---|---|---|
| Valve mounting bolt kit 1/4 – 20 x 2 1/4" | BK866685 | 866685 |
| Valve mounting bolt kit M6 x 60 mm | BK689623M | 689623 |
| Subplate, rear port (inch) | SM4M-10-10 | 682142 |
| Subplate, rear port (metric) | SM4M-10-10M | 866654 |
| Subplate, side port (inch) | SM4ME-10-10 | 682143 |
| Subplate, side port (metric) | SM4ME-10-10M | 866656 |
| Subplate mounting bolt kit 1/4 – 20 x 1 1/2" | BK855992 | 855992 |
| Subplate mounting bolt kit M6 x 40 mm | BK855993M | 855993 |
| Adaptor to CETOP-3 (inch) | SM4A-3-10-10 | 686617 |
| Adaptor to CETOP-3 (metric) | SM4A-3-10-10M | 866655 |
| Adaptor-3 mounting bolt kit 10 – 24 x 1/2" | BK855984 | 855984 |
| Adaptor-3 mounting bolt kit M5 x 12 mm | BK855985M | 855985 |
| Flushing valve (inch) | SM4FV-10/15-10 | 633231 |
| Flushing valve mounting bolt kit 1/4 – 20 x 1" | BK866686 | 866686 |
| Flushing valve mounting bolt kit M6 x 25 mm | BK689629M | 689629 |
| Cable connector | MS3106-14S-2S | 242123 |
| Cable clamp | MS3057-6 | 126058 |

# Standard SM4-15 servo valves

| Model number | Part number |
|---|---|
| **SM4-15(1)3.8-80/40-10** | **855366** |
| **SM4-15(1)3.8-20/200-10** | **855374** |
| SM4-15(1)3.8-200/15-10 | 855361 |
| SM4-15(1)3.8-30/100-10 | 855358 |
| **SM4-15(2.5)9-80/40-10** | **635664** |
| **SM4-15(2.5)9-20/200-10** | **683017** |
| SM4-15(2.5)9-200/15-10 | 855362 |
| SM4-15(2.5)9-300/100-10 | 855369 |
| **SM4-15(5)19-80/40-10** | **689822** |
| **SM4-15(5)19-20/200-10** | **596426** |
| SM4-15(5)19-200/15-10 | 855363 |
| SM4-15(5)19-30/100-10 | 855370 |
| **SM4-15(7.5)28-80/40-10** | **855367** |
| **SM4-15(7.5)28-20/200-10** | **855302** |
| SM4-15(7.5)28-200/15-10 | 855364 |
| SM4-15(7.5)28-30/100-10 | 855371 |
| **SM4-15(10)38-80/40-10** | **682135** |
| **SM4-15(10)38-20/200-10** | **989021** |
| SM4-15(10)38-200/15-10 | 682119 |
| SM4-15(10)38-30/100-10 | 855372 |

Recommended selections shown in bold print.

# SM4-15 accessories

| Description | Model number | Part number |
|---|---|---|
| Valve mounting bolt kit 1/4 – 20 x 2 1/4" | BK866685 | 866685 |
| Valve mounting bolt kit M6 x 60 mm | BK689623M | 689623 |
| Subplate, rear port (inch) | SM4M-15-10 | 989027 |
| Subplate, rear port (metric) | SM4M-15-10M | 866658 |
| Subplate, side port (inch) | SM4ME-15-10 | 989028 |
| Subplate, side port (metric) | SM4ME-15-10M | 866659 |
| Subplate mounting bolt kit 1/4 – 20 x 1 1/2" | BK855992 | 855992 |
| Subplate mounting bolt kit M6 x 40 mm | BK855993M | 855993 |
| Adaptor to .875 port circle (inch) | SM4A-15-M76-10 | 635670 |
| Adaptor to .875 port circle (metric) | SM4A-15-M76-10M | 866660 |
| Adaptor (.875) mounting bolt kit 5/16 – 18 x 1 1/4" | BK688701 | 688701 |
| Adaptor (.875) mounting bolt kit M8 x 35 mm | BK689630M | 689630 |
| Adaptor to CETOP 3 (inch) | SM4A-3-15-10 | 686519 |
| Adaptor to CETOP 3 (metric) | SM4A-3-15-10M | 866661 |
| Adaptor-3 mounting bolt kit 10 – 24 x 1/2" | BK855984 | 855984 |
| Adaptor-3 mounting bolt kit M5 x 12 mm | BK855985M | 855985 |

# Standard SM4-15 servo valves (cont.)

| Model number | Part number |
|---|---|
| **SM4-15(12.5)47-80/40-10** | **683594** |
| **SM4-15(12.5)47-20/200-10** | **627657** |
| SM4-15(12.5)47-200/15-10 | 855365 |
| SM4-15(12.5)47-30/100-10 | 855373 |
| **SM4-15(15)57-80/40-10** | **635678** |
| **SM4-15(15)57-20/200-10** | **681347** |
| SM4-15(15)57-200/15-10 | 855973 |
| SM4-15(15)57-30/100-10 | 514581 |

Recommended selections shown in bold print.

# SM4-15 accessories (cont.)

| Description | Model number | Part number |
|---|---|---|
| Adaptor to CETOP 5 (inch) | SM4A-5-15-10 | 686521 |
| Adaptor to CETOP 5 (metric) | SM4A-5-15-10M | 866662 |
| Adaptor-5 mounting bolt kit 1/4 – 20 x 3/4" | BK855986 | 855986 |
| Adaptor-5 mounting bolt kit M6 x 20 mm | BK855987M | 855987 |
| Flushing valve (inch) | SM4FV-10/15-10 | 633231 |
| Flushing valve mounting bolt kit 1/4 – 20 x 1" | BK866686 | 866686 |
| Flushing valve mounting bolt kit M6 x 25 mm | BK689629M | 689629 |
| Cable connector | MS3106-14S-2S | 242123 |
| Cable clamp | MS3507-6 | 126058 |

# Standard SM4-20 servo valves

| Model number | Part number |
|---|---|
| **SM4-20(1)3.8-80/40-10** | **855380** |
| **SM4-20(1)3.8-20/200-10** | **689944** |
| SM4-20(1)3.8-200/15-10 | 689984 |
| SM4-20(1)3.8-30/100-10 | 855382 |
| **SM4-20(2.5)9-80/40-10** | **689823** |
| **SM4-20(2.5)9-20/200-10** | **689942** |
| SM4-20(2.5)9-200/15-10 | 687270 |
| SM4-20(2.5)9-30/100-10 | 689943 |
| **SM4-20(5)19-80/40-10** | **689824** |
| **SM4-20(5)19-20/200-10** | **688717** |
| SM4-20(5)19-200/15-10 | 855376 |
| SM4-20(5)19-30/100-10 | 855383 |
| **SM4-20(7.5)28-80/40-10** | **689825** |
| **SM4-20(7.5)28-20/200-10** | **855386** |
| SM4-20(7.5)28-200/15-10 | 855377 |
| SM4-20(7.5)28-30/100-10 | 855384 |
| **SM4-20(10)38-80/40-10** | **688706** |
| **SM4-20(10)38-20/200-10** | **514587** |
| SM4-20(10)38-200/15-10 | 684968 |
| SM4-20(10)38-30/100-10 | 687242 |
| **SM4-20(12.5)47-80/40-10** | **855381** |
| **SM4-20(12.5)47-20/200-10** | **855387** |
| SM4-20(12.5)47-200/15-10 | 855378 |
| SM4-20(12.5)47-30/100-10 | 855385 |
| **SM4-20(15)57-80/40-10** | **682121** |
| **SM4-20(15)57-20/200-10** | **683024** |
| SM4-20(15)57-200/15-10 | 855379 |
| SM4-20(15)57-30/100-10 | 687243 |
| **SM4-20(20)76-80/40-10** | **855978** |
| **SM4-20(20)76-20/200-10** | **855980** |
| SM4-20(20)76-200/15-10 | 855976 |
| SM4-20(20)76-30/100-10 | 855979 |

Recommended selections shown in bold print.

# SM4-20 accessories

| Description | Model number | Part number |
|---|---|---|
| Valve mounting bolt kit 5/16 – 18 x 2" | BK866687 | 866687 |
| Valve mounting bolt kit M8 x 50 mm | BK866690 | 866690 |
| Subplate, rear port (inch) | SM4M-20-10 | 682997 |
| Subplate, rear port (metric) | SM4M-20-10M | 866664 |
| Subplate, side port (inch) | SM4ME-20-10 | 682998 |
| Subplate, side port (metric) | SM4ME-20-10M | 866665 |
| Subplate mounting bolt kit 1/4 – 20 x 1 1/2" | BK855992M | 855992 |
| Subplate mounting bolt kit M6 x 40 mm | BK855993M | 855993 |
| Adaptor to CETOP 5 (inch) | SM4A-5-20-10 | 686619 |
| Adaptor to CETOP 5 (metric) | SM4A-5-10-10M | 866666 |
| Adaptor-5 mounting bolt kit 1/4 – 20 x 3/4" | BK855986 | 855986 |
| Adaptor-5 mounting bolt kit M6 x 20 mm | BK855987M | 855987 |
| Flushing valve (inch) | SM4FV-20-10 | 682999 |
| Flushing valve mounting bolt kit 5/16 – 18 x 1 1/4" | BK688701 | 688701 |
| Flushing valve mounting bolt kit M8 x 35 mm | BK689630M | 689630 |
| Filter module (inch) | SM4FM-20/30-10 | 686501 |
| Filter module mounting bolt kit 5/16 – 18 x 2 3/4" | BK855421 | 855421 |
| Filter module mounting bolt kit M8 x 70 mm | BK689624M | 689624 |
| Cable connector | MS3106-14S-2S | 242123 |
| Cable clamp | MS3057-6 | 126058 |



SUNNY ENTERPRISES (PAK)
411 Panorama Centre
Bldg No 2 Raja Ghazanfar Ali Khan Road
SADDAR KARACHI

# Standard SM4-30 servo valves

## Standard response

| Model number | Part number |
|---|---|
| **SM4-30(30)113-80/65-20** | **627621** |
| SM4-30(15)57-80/65-20 | 684988 |
| SM4-30(25)95-80/65-20 | 681349 |

## High response

| Model number | Part number |
|---|---|
| **SM4-30(30)113-80/65-21** | **855349** |
| SM4-30(15)57-80/65-21 | 855337 |

## Robot standard response

| Model number | Part number |
|---|---|
| SM4-30(25)95-80/65-20 | 681346 |

## Robot high response

| Model number | Part number |
|---|---|
| SM4-30(25)95-80/65-21 | 593591 |

Recommended selections shown in bold print.

# SM4-30 accessories

| Description | Model number | Part number |
|---|---|---|
| Valve mounting bolt kit 1/4 – 20 x 1 1/4" | BK866688 | 866688 |
| Valve mounting bolt kit M6 x 35 mm | BK689626M | 689626 |
| Subplate, rear port (inch) | SM4M-30-10 | 627617 |
| Subplate, rear port (metric) | SM4M-30-10M | 866669 |
| Subplate, side port (inch) | SM4ME-30-10 | 627616 |
| Subplate, side port (metric) | SM4ME-10-10M | 866670 |
| Subplate mounting bolt kit 1/4 – 20 x 2 1/4" | BK866685 | 866685 |
| Subplate mounting bolt kit M6 x 60 mm | BK689623 | 689623 |
| Adaptor to CETOP 5 (inch) | SM4A-5-30-10 | 686621 |
| Adaptor to CETOP 5 (metric) | SM4A-5-30-10M | 866671 |
| Adaptor-5 mounting bolt kit 1/4 – 20 x 3/4" | BK855968 | 855986 |
| Adaptor-5 mounting bolt kit M6 x 20 mm | BK855987M | 855987 |
| Flushing valve (inch) | SM4FV-30-10 | 633230 |
| Flushing valve mounting bolt kit 1/4 – 20 x 1 1/4" | BK866688 | 866688 |
| Flushing valve mounting bolt kit M6 x 35 mm | BK689626M | 689626 |
| Cable connector | MS3106-14S-2S | 242123 |
| Cable clamp | MS3057-6 | 126058 |

# Standard SM4-40 servo valves

| Model number | Part number |
|---|---|
| **SM4-40(20)76-80/40-10** | **855392** |
| **SM4-40(20)76-20/200-10** | **689785** |
| SM4-40(20)76-200/15-10 | 855388 |
| SM4-40(20)76-30/100-10 | 855394 |
| **SM4-40(25)95-80/40-10** | **689826** |
| **SM4-40(25)95-20/200-10** | **681348** |
| SM4-40(25)95-200/15-10 | 855389 |
| SM4-40(25)95-30/100-10 | 855395 |
| **SM4-40(30)113-80/40-10** | **686523** |
| **SM4-40(30)113-20/200-10** | **684992** |
| SM4-40(30)113-200/15-10 | 855390 |
| SM4-40(30)113-30/100-10 | 855396 |
| **SM4-40(35)132-80/40-10** | **689827** |
| **SM4-40(35)132-20/200-10** | **855399** |
| SM4-40(35)132-200/15-10 | 855391 |
| SM4-40(35)132-30/100-10 | 855397 |
| **SM4-40(40)151-80/40-10** | **855393** |
| **SM4-40(40)151-20/200-10** | **855983** |
| SM4-40(40)151-200/15-10 | 689951 |
| SM4-40(40)151-30/100-10 | 855398 |

Recommended selections shown in bold print.

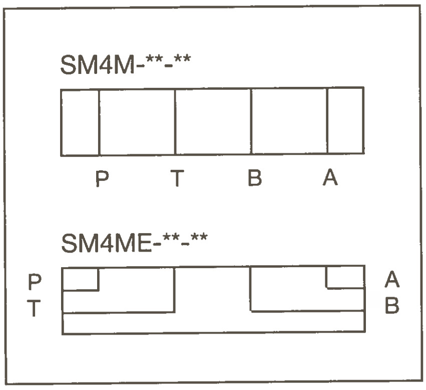
# SM4-40 accessories

| Description | Model number | Part number |
|---|---|---|
| Valve mounting bolt kit 5/16 – 18 x 3" | BK866689 | 866689 |
| Valve mounting bolt kit M8 x 80 mm | BK689628M | 689628 |
| Subplate, rear port (inch) | SM4M-40-10 | 989025 |
| Subplate, rear port (metric) | SM4ME-40-10M | 866673 |
| Subplate, side port (inch) | SM4ME-40-10 | 989026 |
| Subplate, side port (metric) | SM4ME-40-10M | 866674 |
| Subplate mounting bolt kit 1/4 – 20 x 2 1/4" | BK866685 | 866685 |
| Subplate mounting bolt kit M6 x 60 mm | BK689623M | 689623 |
| Adaptor to CETOP 8 (inch) | SM4A-8-40-10 | 686623 |
| Adaptor to CETOP 8 (metric) | SM4A-8-40-10M | 866675 |
| Adaptor-8 mounting bolt kit 1/2 – 13 x 2 1/4" | BK855990 | 855990 |
| Adaptor-8 mounting bolt kit M12 x 60 mm | BK855991M | 855991 |
| Flushing valve (inch) | SM4FV-40-10 | 635681 |
| Flushing valve mounting bolt kit 5/16 – 18 x 1 1/4" | BK688701 | 688701 |
| Flushing valve mounting bolt kit M8 x 35 mm | BK 689630M | 689630 |
| Cable connector | MS3106-14S-2S | 242123 |
| Cable clamp | MS3057-6 | 126058 |

# Accessory products

## Servo valve mounting subplates, rear and side ported models SM4M(E) series

### 1. Functional symbol




### 2. Model and ordering code

SM4M(E)-**-** *

1 2 3 4

**1 Port connection locations**

Blank = Rear ports
E = Side ports

**2 Standard SM4 valve size**

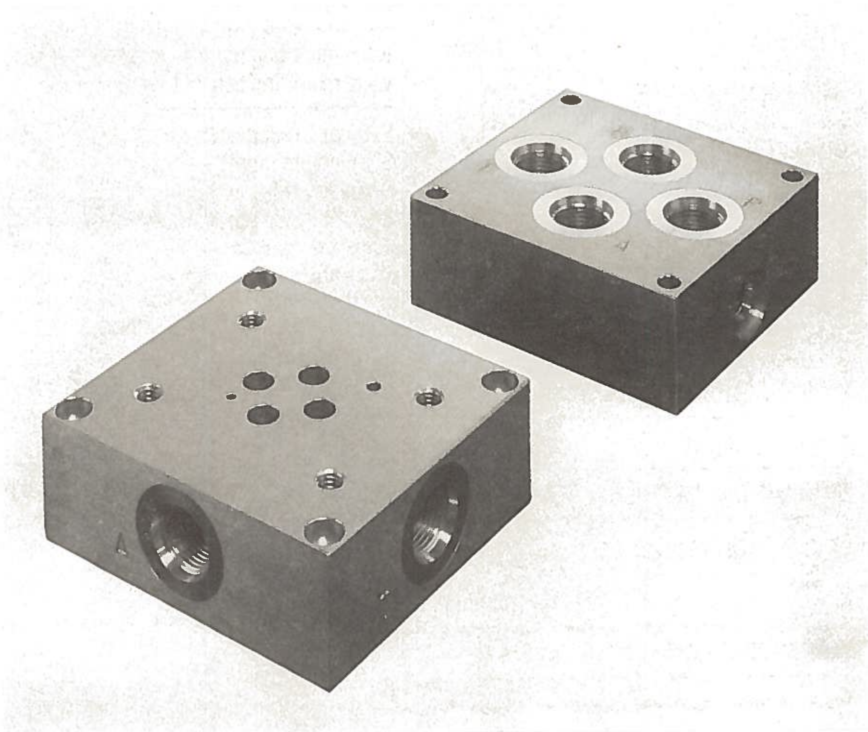
10 = SM4-10
15 = SM4-15
20 = SM4-20
30 = SM4-30
40 = SM4-40

**3 3 Design number**

10 series for SM4M(E) – 10/15/20/40 subplates.
20 series for SM4M(E) – 30 subplates.
Subject to change.
Installation dimensions unaltered for design numbers *0 to *9 inclusive.

**4 Metric suffix**

M – Metric version to NG (ISO) standards.



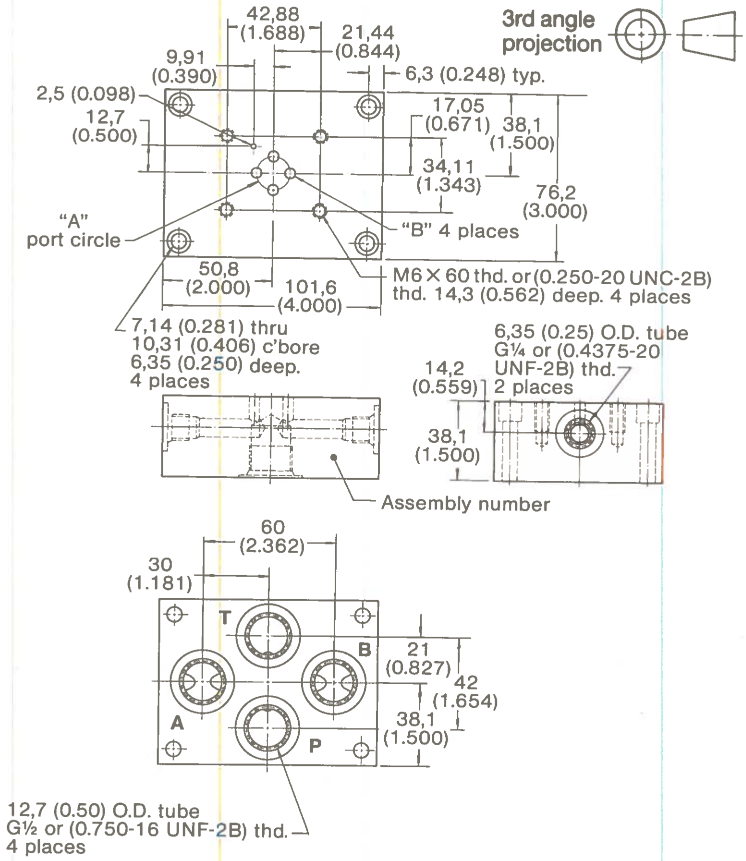
### 3. SM4M(E) operating data

| | | |
|---|---|---|
| Maximum pressure when used with: | | |
| SM4-10/15/20/40 valves | | 210 bar (3000 psi) |
| SM4-30 valves | | 140 bar (2000 psi) |
| Hydraulic fluids and temperature ranges | | See page 55. |
| Installation dimensions | | See pages 46 to 49. |
| Mass (weight): | SM4M(E)-10/15 | 0,73 kg (1.6 lb) |
| | SM4M(E)-20 | 0,91 kg (2.0 lb) |
| | SM4M(E)-30 | 1,8 kg (4.0 lb) |
| | SM4M(E)-40) | 1,8 kg (4.0 lb) |

## 4. SM4M(E) installation dimensions; mm (inches)

### Subplates – rear port

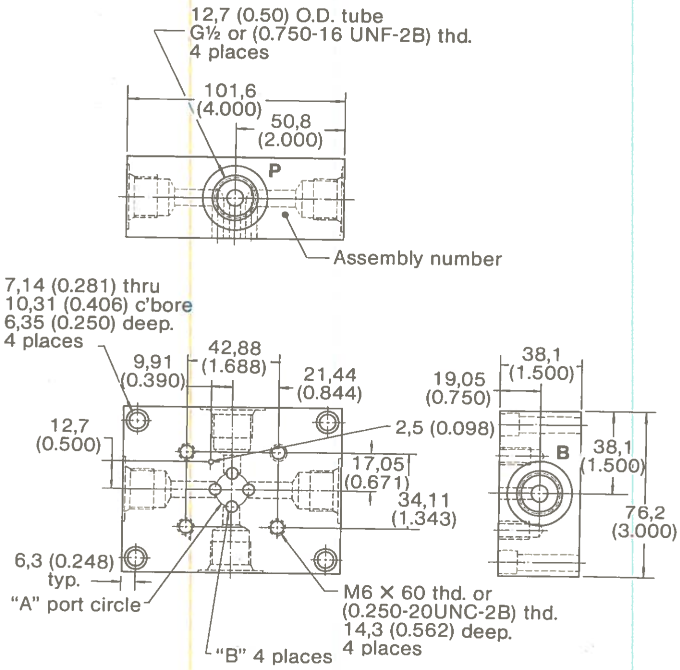
SM4M-10-10
SM4M-15-10
SM4M-10-10M
SM4M-15-10M




| | A Port circle | B Port dia. |
|---|---|---|
| SM4M-10 | 15.88 (.625) | 4.85 (.191) |
| SM4M-15 | 23.80 (.937) | 7.94 (.312) |

### Subplates – side port

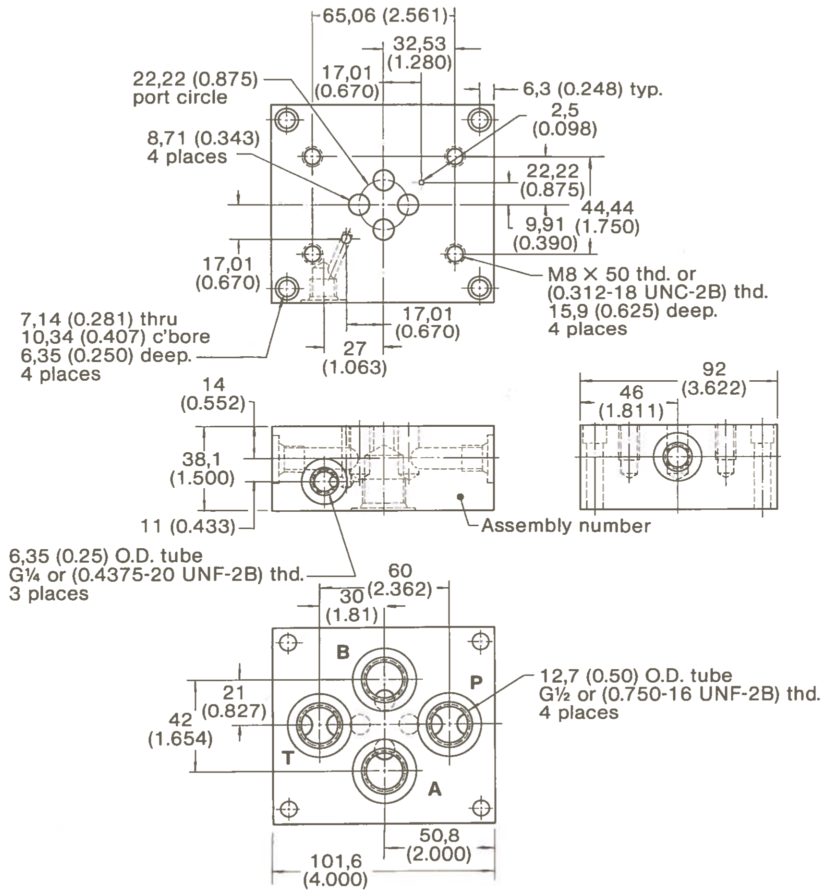
SM4ME-10-10
SM4ME-15-10
SM4ME-10-10M
SM4ME-15-10M




| | A Port circle | B Port dia. |
|---|---|---|
| SM4ME-10 | 15.88 (.625) | 4.85 (.191) |
| SM4ME-15 | 23.80 (.937) | 7.94 (.312) |

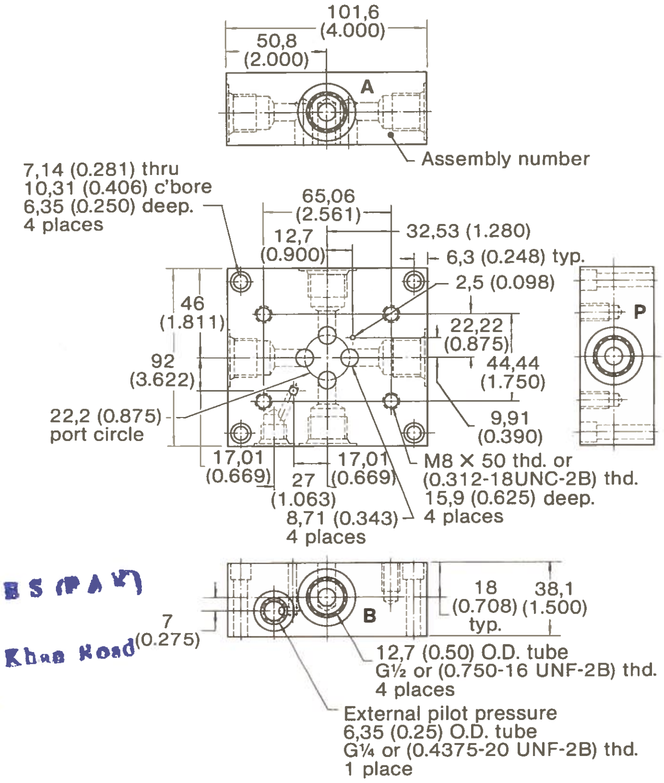
## Subplates – rear port

SM4M-20-10
SM4M-20-10M



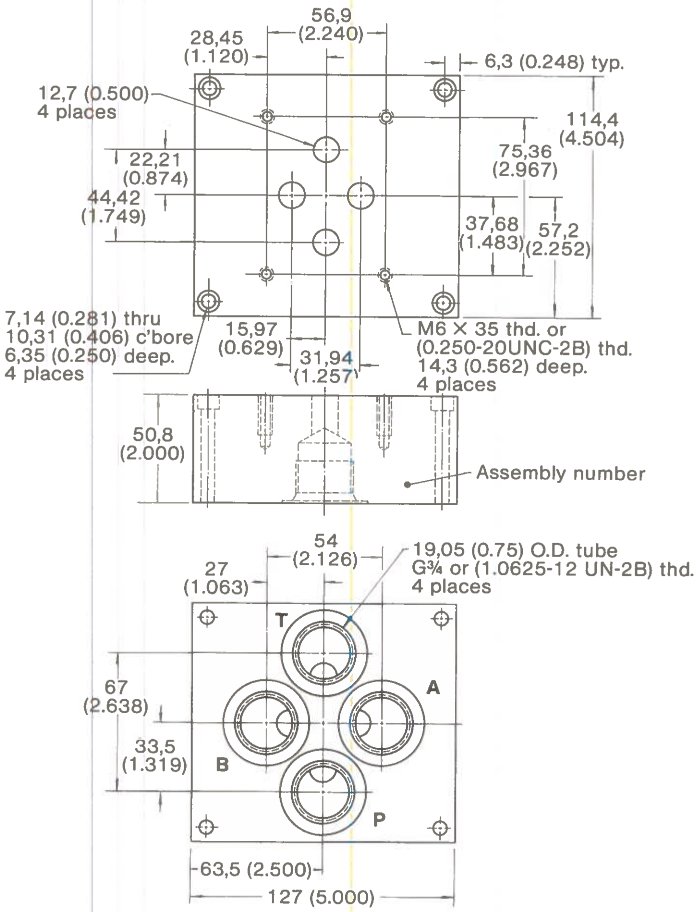

## Subplates – side port

SM4ME-20-10
SM4ME-20-10M



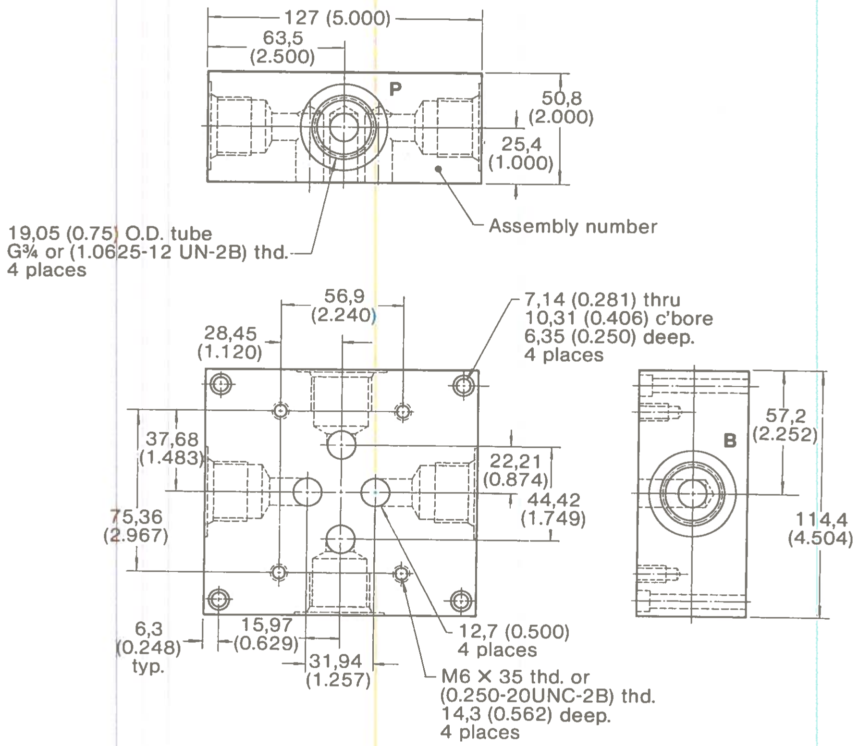
## Subplates – rear port

SM4M-30-20
SM4M-30-20M



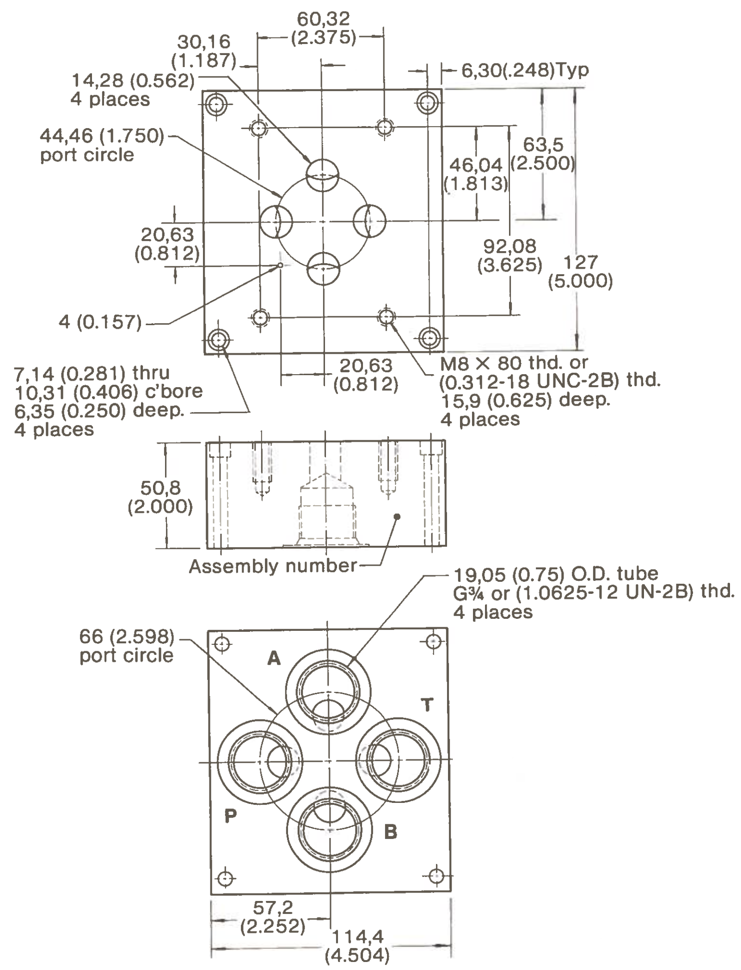

## Subplates – side port

SM4ME-30-20
SM4ME-30-20M



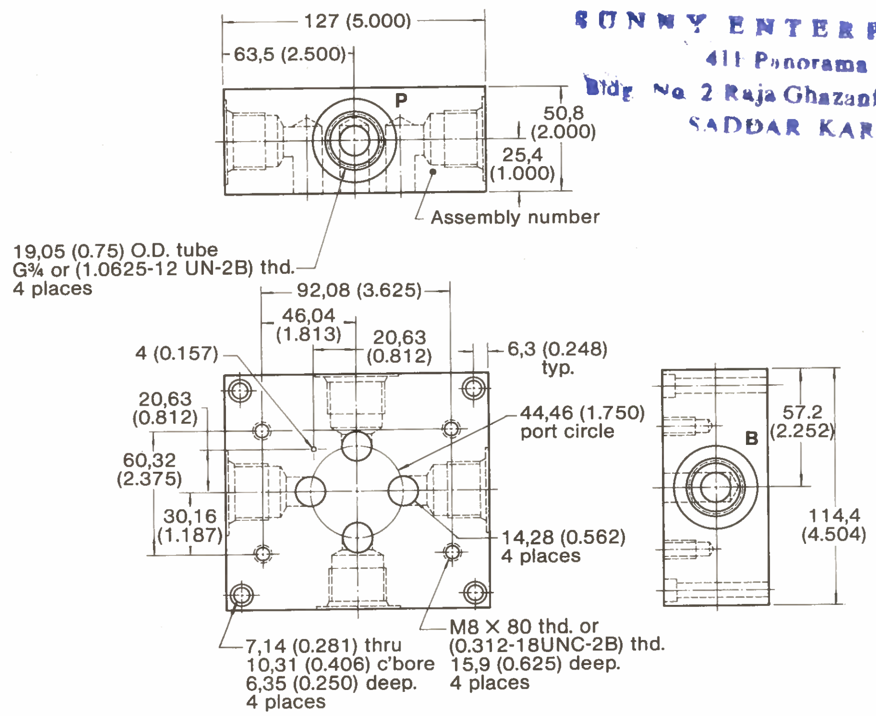
## Subplates – rear port

SM4M-40-10
SM4M-40-10M



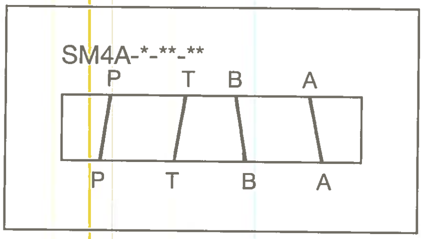

## Subplates – side port

SM4ME-40-10
SM4ME-40-10M



# Servo valves adapter manifolds SM4A series

## 1. Functional symbol




## 2. Model and ordering code

SM4A-*-**-** *

1 2 3

### 1 Mounting interface

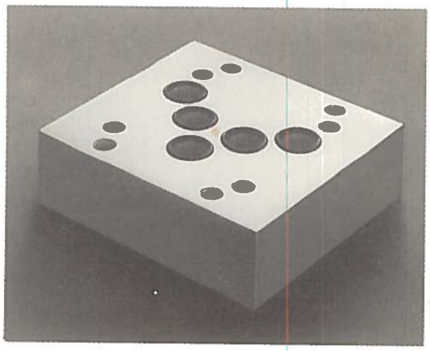
| Code | IS04401 mounting | to | standard SM4 valve |
|---|---|---|---|
| 3-10 | 03 | | SM4-10 |
| 3-15 | 03 | | SM4-15 |
| 5-15 | 05 | | SM4-15 |
| 5-20 | 05 | | SM4-20 |
| 5-30 | 05 | | SM4-30 |
| 8-40 | 08 | | SM4-40 |

### 2 Design number

10 Series for SM4A-10/15/20/40.
20 series for SM4A-30.
Subject to change.
Installation dimensions unaltered for design numbers *0 to *9 inclusive.

### 3 Metric suffix

M – Metric version to NG (ISO) standards.

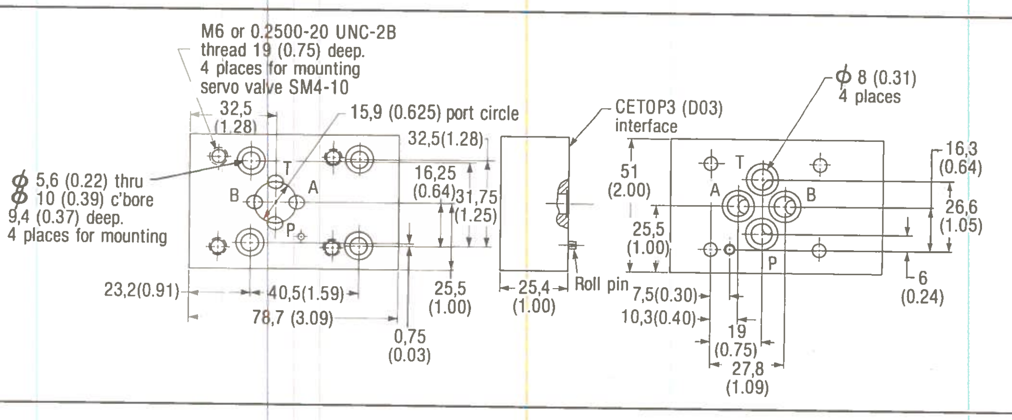


## 3. SM4A operating data

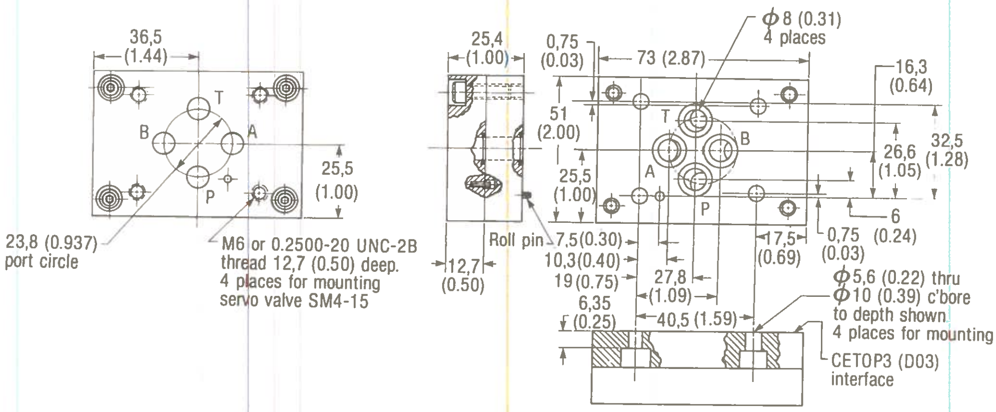
| | |
|---|---|
| Maximum pressure when used with:<br>SM4-10/15/20/40 valves<br>SM4-30 valves | <br>210 bar (3000 psi)<br>140 bar (2000 psi) |
| Hydraulic fluids and temperature ranges | See page 55. |
| Installation dimensions | See below and page 51. |
| Mass (weight):<br>SM4A-3-10-10 (M)<br>SM4A-3-15-10 (M)<br>SM4A-5-20-10 (M)<br>SM4A-5-15-10 (M)<br>SM4A-5-30-10 (M)<br>SM4A-8-40-10 (M) | <br>0,240 kg (0.53 lb)<br>0,240 kg (0.53 lb)<br>0,439 kg (0.97 lb)<br>0,499 kg (1.10 lb)<br>0,625 kg (1.38 lb)<br>2,013 kg (4.44 lb) |

## 4. SM4A installation dimensions; mm (inches)

### Adapters
SM4A-3-10-10
SM4A-3-10-10M

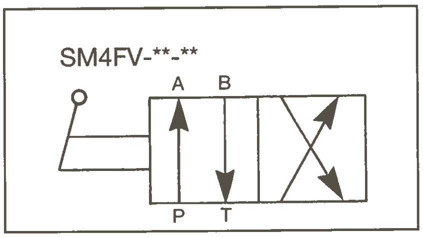



### Adapters
SM4A-3-15-10
SM4A-3-15-10M



# Servo valve flushing valves SM4FV series

## 1. Functional symbol

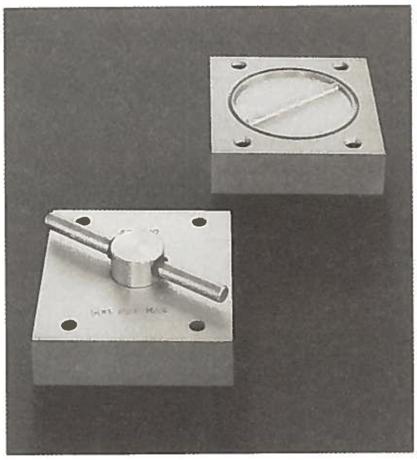



## 2. Model and ordering code

SM4FV-**-**
[1] [2]

### [1] Nominal size

10/15 = SM4-10
10/15 = SM4-15
20 = SM4-20
30 = SM4-30
40 = SM4-40



### [2] Design number

10 series for SM4-10/15/20/40.
20 series for SM4-30.
Subject to change.
Installation dimensions unaltered for design numbers *0 to *9 inclusive.

## 3. SM4FV operating data

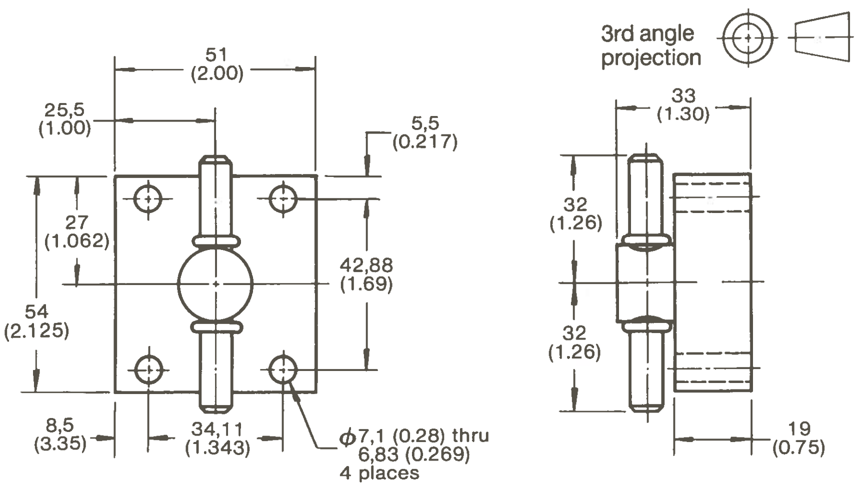
| | |
|---|---|
| Usage | To be fitted as a temporary substitute for a servo valve on new installations, or on those that have undergone major repair. The module allows simulations of the servo valve by rotation of the flushing valve handle. The system actuator can then operate in either direction while the application's pumping system flushes in-built contaminant through and out of the system. A servo valve should not be installed until after an acceptable contamination level is attained. For further information, see page 55. |
| Maximum flushing pressure | 35 bar (500 psi) |
| Hydraulic fluids, temperature ranges and filtration recommendations | See page 55. |
| Installation dimensions | See below and page 53. |
| Mass (weight): | |
| SM4FV-15 | 0,15 kg (0.32 lb) |
| SM4FV-20 | 0,27 kg (0.58 lb) |
| SM4FV-30 | 0,63 kg (1.37 lb) |
| SM4FV-40 | 0,77 kg (1.70 lb) |

## 4. SM4FV installation dimensions; mm (inches)

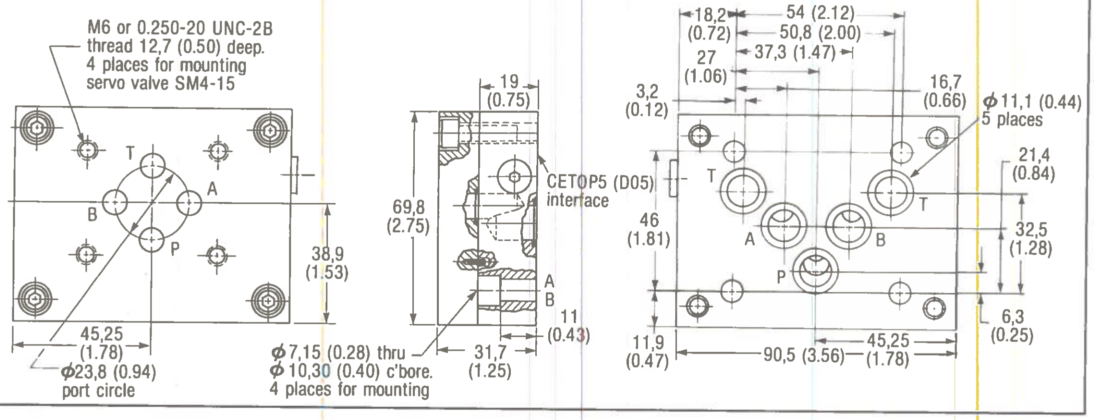
### Flushing valves

SM4FV-10/15-10

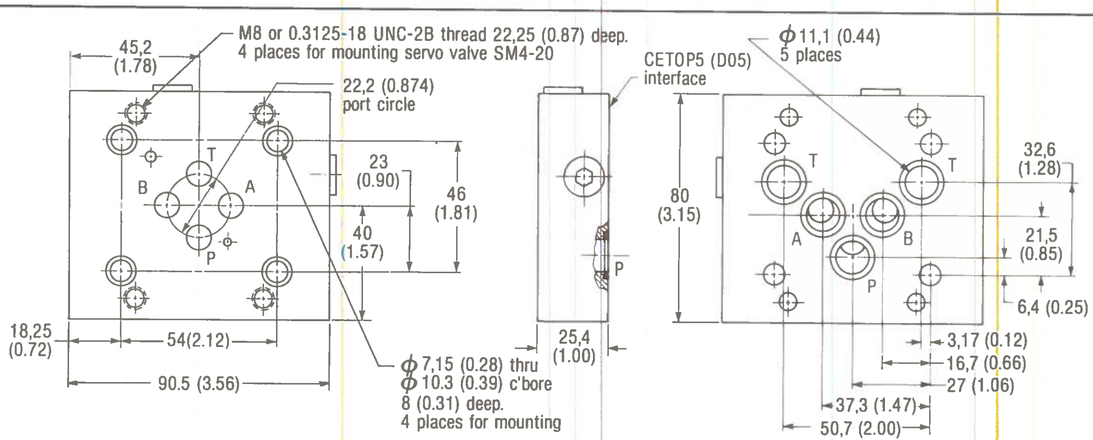
Vickers model SM4FV-10/15-10 flushing valve is designed for use with Vickers SM4-10 and SM4-15 series servo valves.



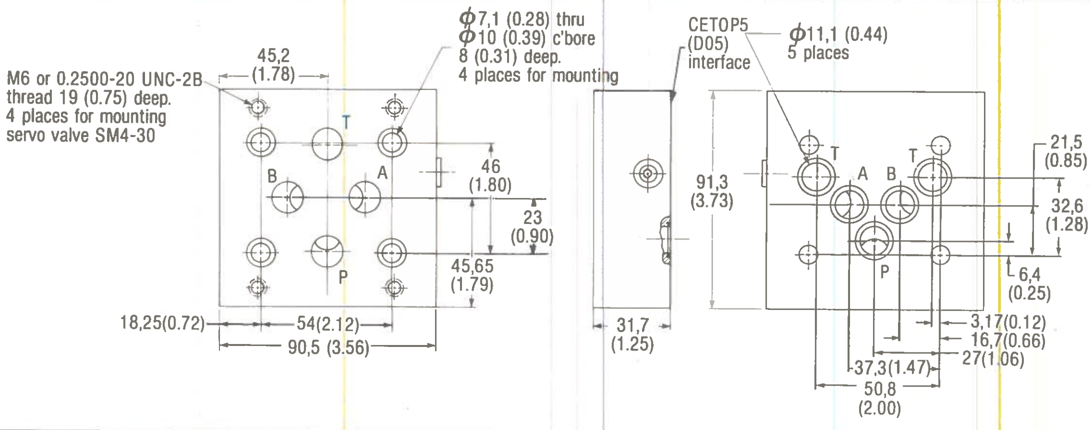
## Adapters
SM4A-5-15-10
SM4A-5-15-10M



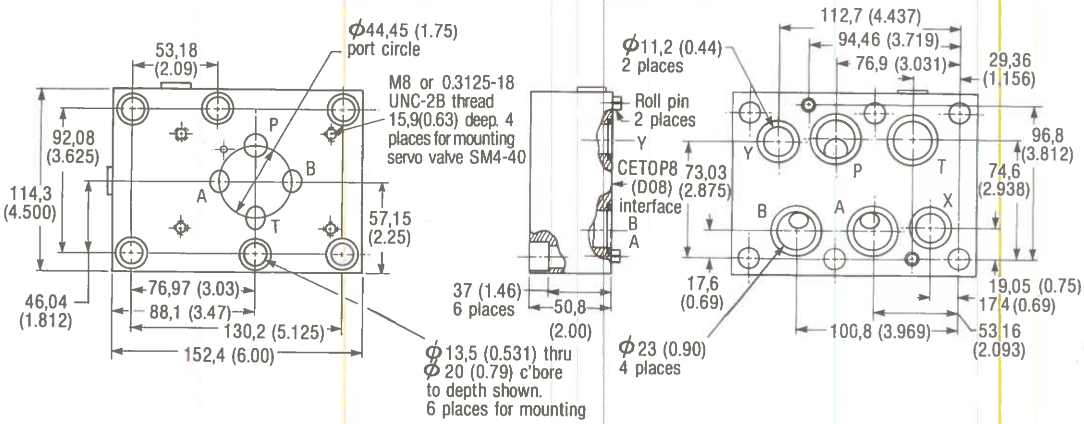

## Adapters
SM4A-5-20-10
SM4A-5-20-10M




## Adapters
SM4A-5-30-20
SM4A-5-30-20M

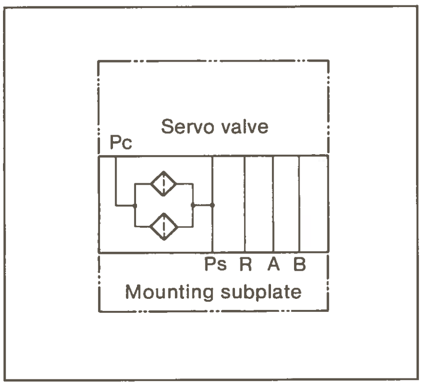



## Adapters
SM4A-8-40-10
SM4A-8-40-10M



# Servo valve filter module SM4FM-20-10 design

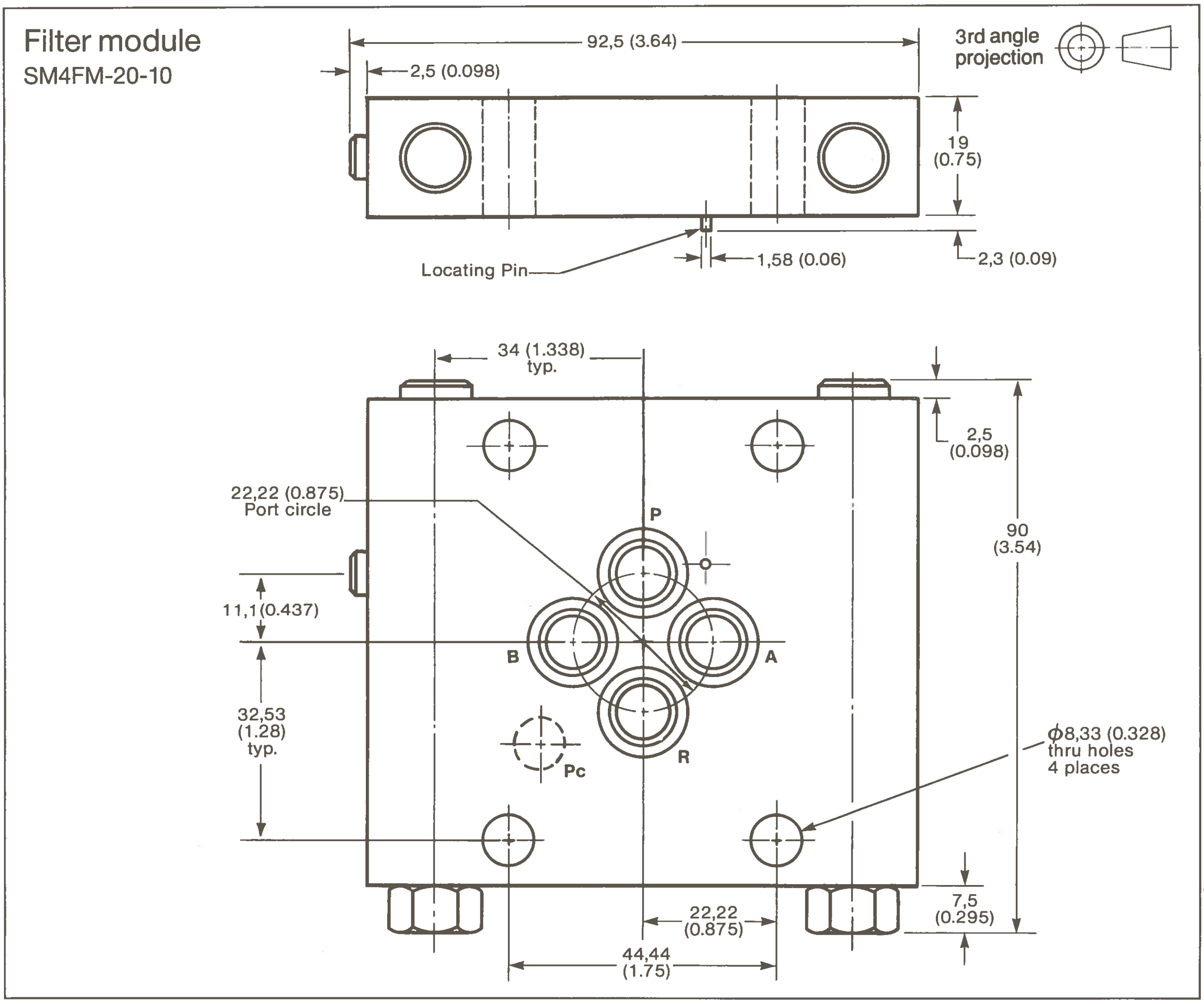
## 1. Functional symbol



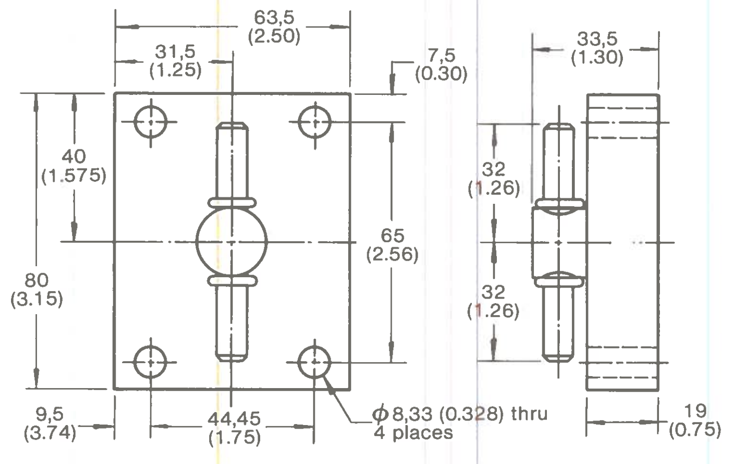

## 2. Operating data

| | |
|---|---|
| Usage | To be used with those standard SM4-20 valves having an activated external pilot port X (5th port) and which, because of exceptional contamination risk, may require additional first stage filtration.<br>Note: To activate fifth port on Vickers SM4-20 series servo valves, see page 24. |
| Maximum pressure | 210 bar (3000 psi) |
| Installation dimensions | See below |
| Mass (weight): | 1,05 kg (2.3 lb) |
| Servicing | Should filters become clogged they can be removed for cleaning by simply removing their respective access plugs. Neither the module nor the servo valve need be removed.<br>Spare filter screens can be ordered by part number 683595, two required. |

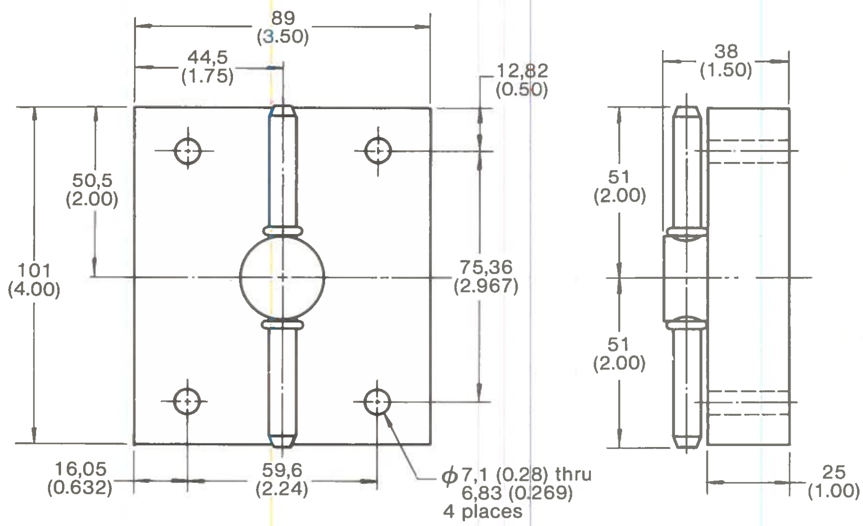
## 3. SM4FM installation dimensions; mm (inches)



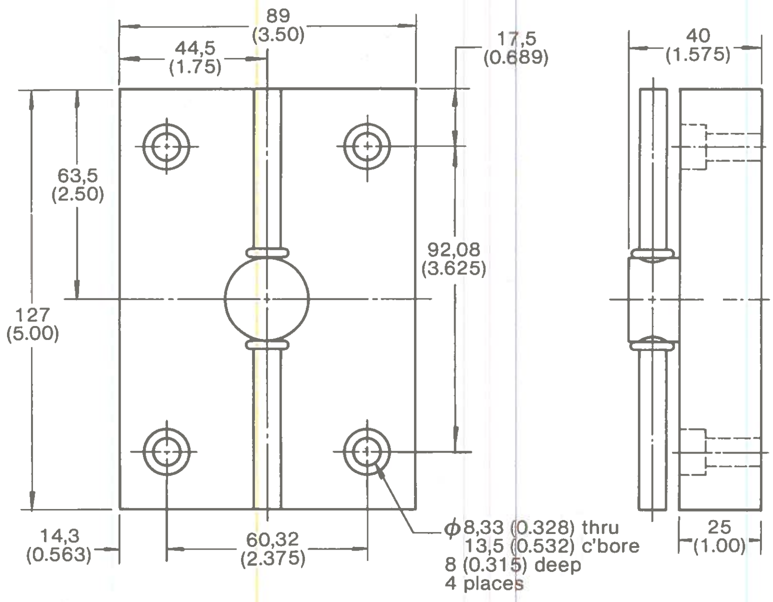
## Flushing valves
SM4FV-20-10




## Flushing valves
SM4FV-30-20




## Flushing valves
SM4FV-40-10



# Further information

Hydraulic fluids, temperature ranges and filtration/contaminant control

## Fluid types

Antiwear hydraulic oils of viscosity grades from 32 cSt (150 SUS) to 48 cSt (225 SUS), at 38°C (100°F), are recommended. Please consult Vickers if other fluids, e. g. fire-resistant types, are to be used.

For general information about antiwear hydraulic oils, see:

a) Data sheet about hydraulic fluids in industrial applications. Available on request and also in the main Vickers industrial products catalog.
b) Fluid suppliers publications.

## Viscosity/temperature limits

Extreme viscosity limits of 220 cSt (1000 SUS) maximum and 13 cSt (70 SUS) minimum should not be exceeded at the respective operating temperature limits of 0°C (32°F) and 85°C (185°F). However, to obtain optimum service life from both the oil and the hydraulic system, Vickers recommends that the oil temperature should not exceed 65 C (150 F).

## Contaminant control

Contaminant in hydraulic systems is now recognized as the most likely cause of any malfunction or failure of hydraulic equipment. Dependent on the nature, size and/or amount of contaminant, it can cause:

- Machine malfunction, particularly when operating toward maximum capacity.
- Risk of frequent breakdowns under the same conditions.
- Production rates below schedule.
- High product scrap rates and quality faults.

## Nature of contaminant

Contaminant can be either particle contaminant or the product (s) of fluid degradation.

## Particle contaminant

can be of metal, rubber, plastic, dirt, dust, fiber, sand, paint, etc. Several types may be present at any time. It can enter the fluid at any time after the fresh clean fluid has been shipped by the fluid manufacturer. There is usually little likelihood that fresh fluid became contaminated during the refining and blending processes.

## Fluid degradation

shows in one or more of the following ways:

- Oxidation and/or the formation of gummy deposits and sludge from the combined effects of high temperatures, air, water and particle contaminant. These can increase viscosity, cause gummy deposits to coat moving parts, clog orifices and small passages, thus impairing smooth mechanical movements, and form sludge.
- Unstable emulsions of poor lubricity formed when water accidently emulsifies with oil. These impair smooth movements and promote wear.
- Air bubbles in the fluid, particularly at low pressures. In excess, they cause noise in pumps and valves, leading to erratic or spongy machine movements, premature wear and failure.

## Filtration Recommendations

Adequate fluid filtration for protection from environmental contaminant ingression and generated contaminants must be provided to ensure reliable system performance. Component filtration requirements are stated in terms of cleanliness levels based on the proposed International Organization for Standards (ISO) cleanliness code which defines maximum contaminant particle count levels in the system fluid. The code also covers particle counting methods and calibration.

Servo components need protection from silting by very small particles. We recommend ISO cleanliness code 15/11 which defines fluid contamination particle count of less than 320 per milliter greater than 5 micrometre size, and 20 per milliter greater than 15 micrometre. This protection can be provided by 10-micrometer elements in the Vickers OFP pressure line filters. In most systems, these filters will be adequate to maintain the ISO cleanliness code of 15/11. However, should the environment be particularly dirty, finer filtration is recommended.

For more in-depth information about filtration, refer to “Effective Contamination Control in Fluid Power Systems” (Vickers bulletin 348), and OFP pressure line filter installation drawings 522175 and 522180.

A servo valve should not be installed until after an acceptable contamination level is attained.

## Installation and commissioning

Before installing the servo valve, it is essential to carry out an effective flushing procedure on each installation to remove in-built contaminant from new systems or those that have undergone major repairs. To this end, temporarily install the flushing valve in place of the servo valve. See pages 52 and 53 for more details.

On completion of the flushing operation, remove the flushing module and immediately install the servo valve. There is no restriction on its mounting attitude.

Vickers will be pleased to advise or assist further on flushing and other aspects of installation and commissioning in respect to your application. You should find the sections on “Filtration recommendations” and “Contaminant control” above particularly useful.

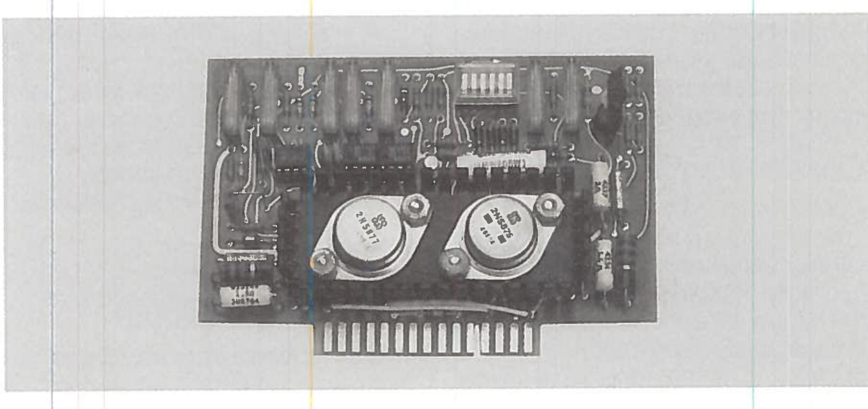
# EM Servo electronics

Vickers amplifiers, power supplies, and function modules provide a convenient and economical package of electronics for closed loop servo control.

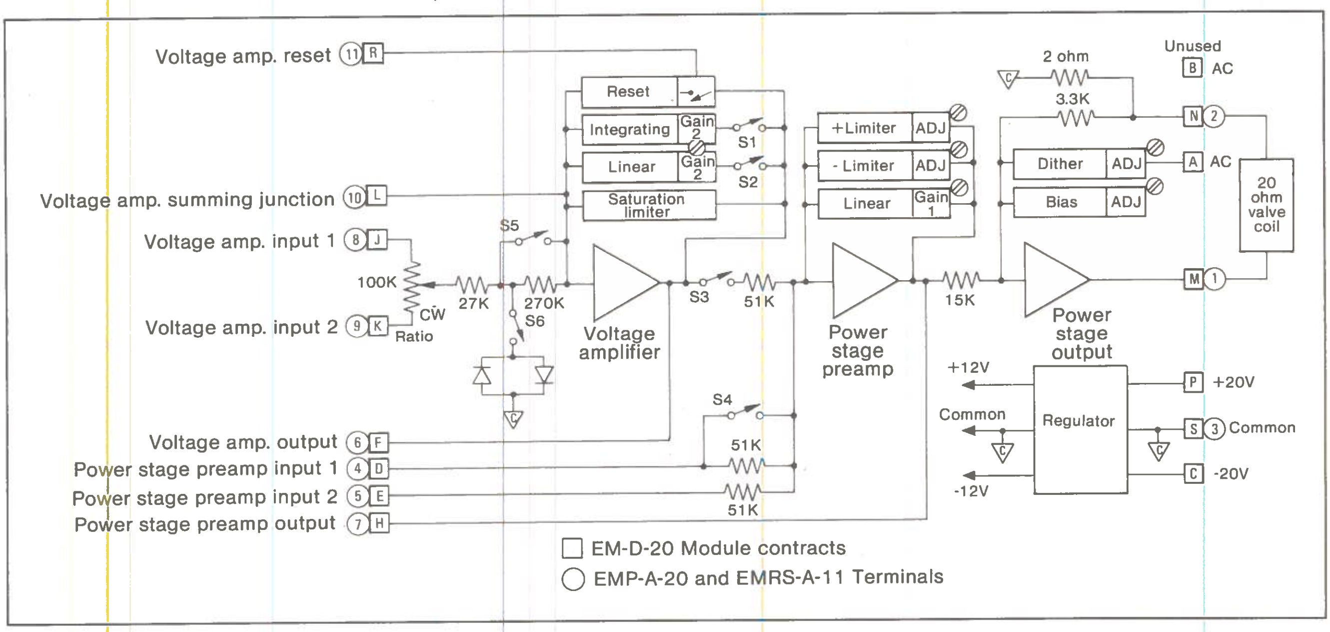
| Basic model | Product summary | Part number |
|---|---|---|
| EM-D-20 | Servo amplifier module; linear and integrating modes. Power output stage ±600 mA into 20 Ohm load. Amplifier gain: 110 to 1520 mA/V | 751233 |
| EM-K-10 | Linear ramp module; independent up and down ramps. Ramping time 0 to 5 sec.; can be extended. Input: ±10 VDC Output: ±10 VDC 2 mA | 421092 |
| EM-J-10 | Programmer module; provides 5 analog command levels by potentiometer adjustments, assorted relay logic and LED indicator lamps. | 635392 |
| EMRS-A-11 | Power supply; capacity 1 module. Input: 115 V AC 60 Hz | 632885 |
| EMP-A-20 | Power supply; capacity 4 modules. Input: 115/230 V AC 50 – 60 Hz | 751225 |

In addition, EEA servo electronics (European style) are available for use in systems requiring card or rack mounted controls. Please refer to pages 65 to 69 for specific details.

## EM-D-20 servo amplifier module



## 1. Circuit and connections



## 2. EM-D-20 operating data

### Usage

The EM-D-20 amplifier can be plugged into the EMRS-A-11 single-module power supply or the EMP-A-20 four-module power supply to drive any one of the SM4 valves in this catalog.

### Design

The module consists of a power output stage and a general purpose voltage amplifier. The voltage amplifier may be used independently or in conjunction with the power output stage.
Adjustment of current limiters and bias in the output stage permits the unit to drive single polarity servo valves, bipolar servo valves or other electrically modulated valves.
The voltage amplifier stage may be set up as either a linear or an integrating amplifier depending on the setting of internal switches. Other switches allow selection of a low or high gain range and selection of input error limiting for velocity systems. An integrator reset circuit and an output saturation limiter are also provided.

## EM-D-20 installation and commissioning (startup) guidelines

This amplifier is designed to control SM4 servo valves in closed loop, position, velocity, or pressure control circuits. In addition, the voltage amplifier portion of the unit may be used independently for other related control circuit functions.

## EM-D-20 ratings

### Power stage

(Combined power output and power pre-amp stages)

| | |
|---|---|
| Output, at terminals 1 and 2 | ±600 mA into 20 Ohm load |
| Bias range | ±400 mA |
| Gain range | 110 to 1520 mA/V |
| Dither range | 0 to 40 mA |
| Drift due to temperature | <0,4 mA/°C (0.2 mA/°F) |
| Drift vs. supply voltage | <1 mA/V at maximum gain at null |
| warm-up drift (30 minutes) | <2 mA |
| Drift vs. time (24 hours) | <1 mA |
| Frequency response | 3 dB down at 300 Hz, maximum gain and ±45 mA |

### Power preamp stage

| | |
|---|---|
| Output, at terminal 7 | ±6V x ±0,5 mA |
| Gain | 1 to 13,8 V/V |
| Limiting | Adjustable from ±6V to 0 V |

### Voltage amplifier stage

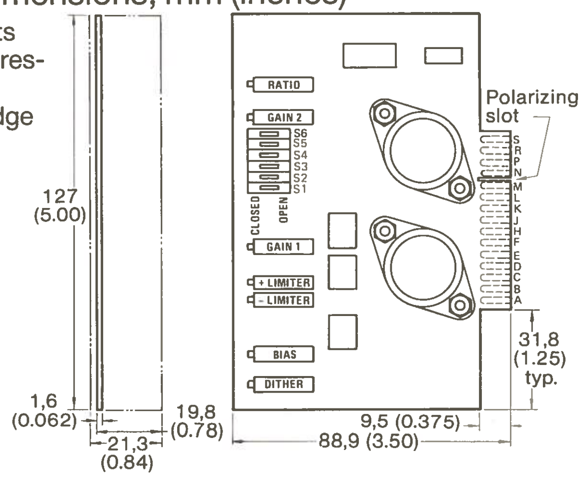
| | |
|---|---|
| Output, at terminal 6 | ±8 x 2mA |
| Gain range with ratio potentiometer on center: Linear, low range | 0,08 V/V to 1,09 V/V |
| Linear, high range | 0,49 V/V to 6,7 V/V |
| Integrating, low range | 1,5 V/sec V to 21,4 V/sec V |
| Integrating, high range | 9,6 V/sec V to 133 V/sec V |
| Drift due to temperature | <0,002 V/°C (0.001 V/° F) approx. at max. gain |
| Drift vs. supply voltage | <0,010 V/V at max. gain |
| Warm-up drift (30 minutes) | <0,02 V |
| Drift vs. time (24 hours) | <0,02 V |
| Frequency response | 3 dB down at 1000 Hz, with maximum gain |

### General

| | |
|---|---|
| Ambient temperature range | 0 to 50°C (32 to 122°F) |
| Mass (weight) without amplifier | 0,45 kg (1 lb) |
| Installation and commissioning (start-up) guide | See below and pages 58 and 59. |

### 3. Installation dimensions; mm (inches)

Note: Switch contacts are closed when depressed side of switch is positioned toward edge of the board.



## Limiter ranges

Limiter ranges are specified for the bias control at 0 mA. Limiter ranges are offset by the amount of bias when output is biased.

## Inversion

Each of the three stages of the amplifier shown in the block diagram, page 56, inverts the input polarity. Positive input gives negative output and negative input gives positive output.

## Reset

When terminal 11, page 56, is grounded an integrator reset function is enabled, causing the voltage amplifier output to go virtually instantaneously to zero or near zero. An open circuit on terminal 11 restores normal operation. Gain of the voltage amplifier in the reset mode with the ratio potentiometer centered is .021 V/V with S5 closed and .003 V/V with S5 open.

## Switch functions (page 56)

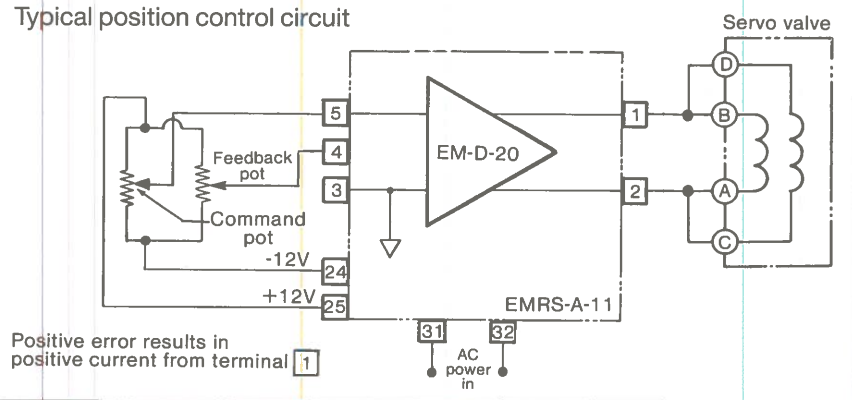
| | |
|---|---|
| S1 | – Puts voltage amplifier in integrating mode when closed. |
| S2 | – Puts voltage amplifier in linear mode when closed. |
| S1, S2 | – When both are open, voltage amplifier operates open loop for use as a high gain of approximately 20,000. |
| S3 | – Corrects voltage amplifier output to power stage input when closed. Voltage amplifier operates independantly when open. |
| S4 | – Bypasses the power stage input resistor at terminal 4 when closed, making the power stage summing junction available at terminal 4. |
| S5 | – Places the voltage amplifier in low gain range when open, and high gain range when closed. |
| S6 | – Adds a code threshold limiter when closed. This limits the maximum error signal to reduce overshoot when using the voltage amplifier as an integrator in velocity systems. Switch S5 must be open to use this feature. |

## Potentiometer adjustments (see diagrams page 56)

| | |
|---|---|
| Dither | – Adjusts dither output from 0 mA (CCW) to 40 mA RMS (CW). |
| Bias | – Biases the power stage output with no input from –400 mA (CW), through 0 mA (center) to + 400 mA (CCW). |
| – Limiter | – Limits output current in negative direction from 0 mA (CCW) to – maximum output capability (CW). |
| + Limiter | – Limits output in positive direction from 0 mA (CCW) to + maximum output capability (CW). |
| Gain 1 | – Adjusts gain of power stage from minimum (CCW) to maximum (CW). |
| Gain 2 | – Adjusts gain of voltage amplifier stage from minimum (CCW) to maximum (CW). |
| Ratio | – Adjusts ratio of inputs at terminals 8 and 9. Center is for equal inputs. CW rotation increases 8/9 ratio. CCW rotation decreases 8/9 ratio. |

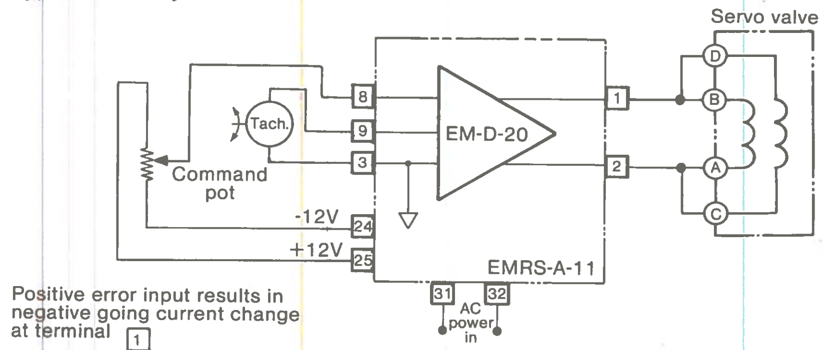
## EM-D-20 application examples

Typical position control circuit



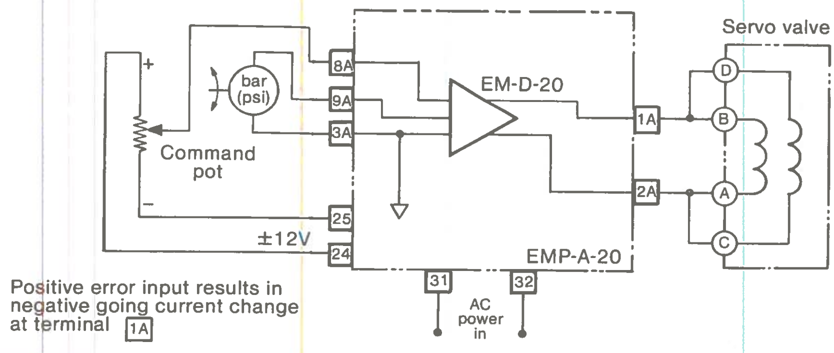

Positive error results in positive current from terminal $\boxed{1}$

Typical velocity control circuit




Positive error input results in negative going current change at terminal $\boxed{1}$

Typical pressure control circuit




Positive error input results in negative going current change at terminal $\boxed{1A}$

## Potentiometer and switch settings on EM-D-20 amplifier module

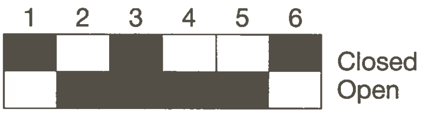
### Switch settings

Typical positional control


Darkend area represents depressed side of switch.

### Switch settings

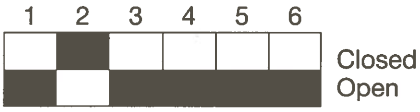
Typical velocity control




Darkend area represents depressed side of switch.

### Switch settings

Typical pressure control

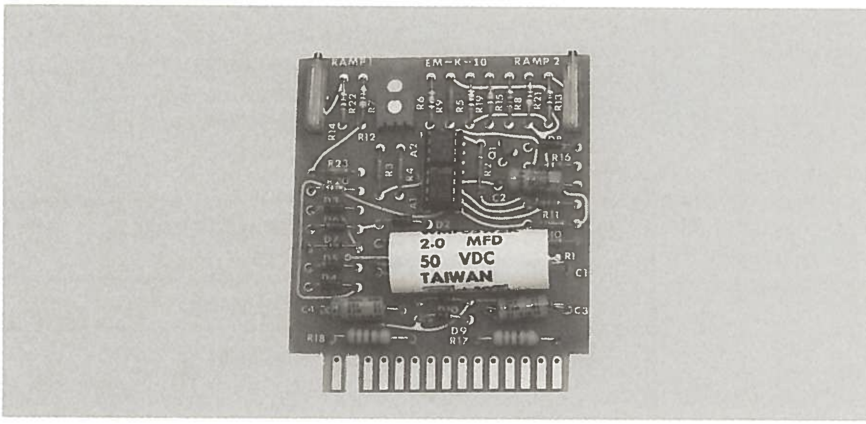



Darkend area represents depressed side of switch.

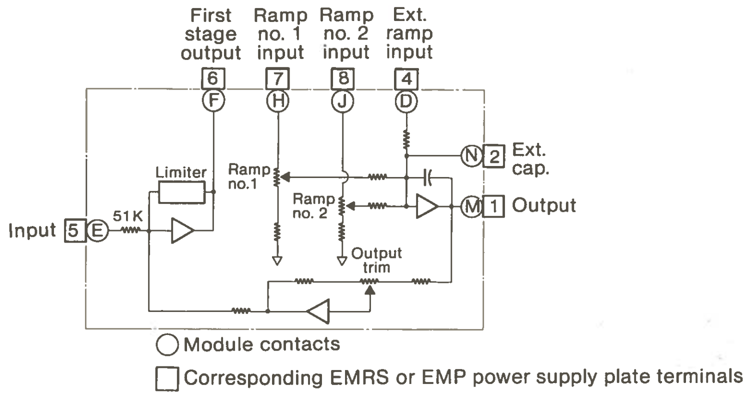
### Potentiometer adjustment settings

| | |
|---|---|
| Dither | 5 – 20 % |
| Bias | Zero mA output at zero input |
| ± Limiters | ±200 mA |
| Gain 1 | As required |
| Gain 2 | As required |
| Ratio | As required |

# EM-K-10 ramp module




## 1. Circuit and connections




## 2. EM-K-10 operating data

### Usage

This ramp module converts step changes in input signals to ramped signals for smooth transition from one operating level to another.

Ramping time can be adjusted from virtually instantaneous response to 5 seconds for full range. Extended ramp times can be obtained with additional external capacitors. See specifications and curves for details.

When used with an EM-D-20 servo amplifier, the ramp module provides a means of controlling speed in positioning systems, acceleration and deceleration in speed control systems, and the rate of pressure change in pressure control systems.

See application examples on page 61.

### Design

The EM-K-10 consists of a linear circuit capable of accepting 0 to ±10V DC step input voltage levels. Two ramp rate potentiometers allow adjusted ramp rates between 0.03 and 0.5 seconds per Volt output change. Extended ramp rates up to 25 sec/V output change can be obtained by the addition of external mylar or similar quality capacitors with a 50 Volt or higher rating. The ramp rate potentiometers are selected externally by the use of a simple diode steering circuit or contact closures.

In addition to the module mounted ramp rate potentiometers, provision has been made for the addition on an infinite number of externally located ramp rate potentiometers.

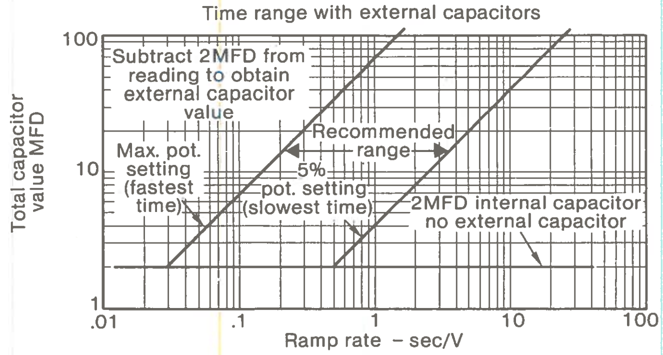
## EM-K-10 ratings

| | |
|---|---|
| Input voltage<br>Input impedance<br>Output voltage<br>Output load impedance<br>Output current<br>Ramp rate adjustment | −10 V to +10V DC<br>51 k Ohm<br>−10 V to +10V DC<br>5 k Ohm minimum<br>2 mA maximum<br>0,03 to 0,5 sec/V output change with addition of external capacitors. See page 61. |
| Number of independent ramp rate adjustments | Two potentiometers on module |
| Input/output relationship | ±1% of maximum input voltage |
| Extended ramp rates | Up to 25 sec/V output change with addition of external capacitors. See below. |
| Multiple ramp rates | Terminal available for external connection of additional potentiometers and relays. |
| Ramp time characteristics and typical performance | See diagrams below. |
| General<br>Ambient temperature range<br>Installation dimensions<br>Mass (weight): | <br>0 to 50°C (32 to 122°F)<br>See page 61.<br>0,45 kg (1 lb) |

## Ramp time characteristics

### Extended ramp ranges

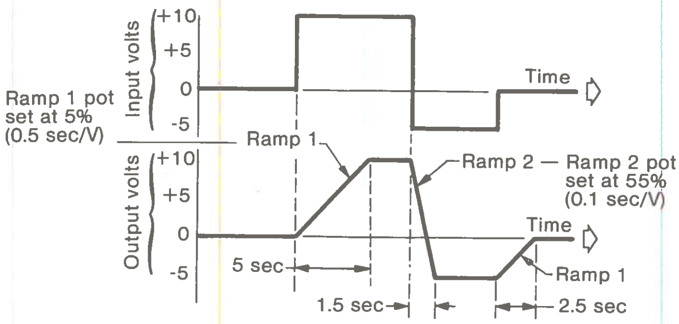
Ramp rates can be extended beyond that shown above by adding external capacitors between terminals 1 and 2 (page 59). Capacitors should be mylar or similar quality with 50V or higher rating.




## EM-K-10 performance characteristics

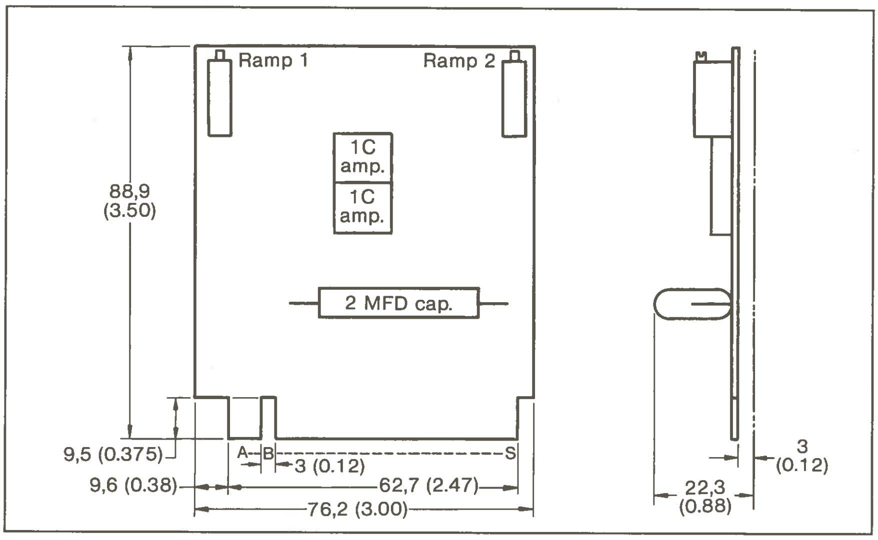
### Performance example

(Ramp 1 and 2 potentiometers connected with diodes as shown in circuit 2 on page 61).




| | |
|---|---|
| Ramp Time | = ramp rate (sec/Volt) x Volts change. |
| Examples: | |
| First ramp time | = 0.5 sec/Volt x 10 Volts<br>= 5 sec |
| Second ramp time | = 0.1 sec/Volt x 15 Volts<br>= 1.5 sec |
| Third ramp time | = 0.5 sec/Volt x 5 Volts<br>= 2.5 sec. |

## 3. Installation dimensions; mm (inches)

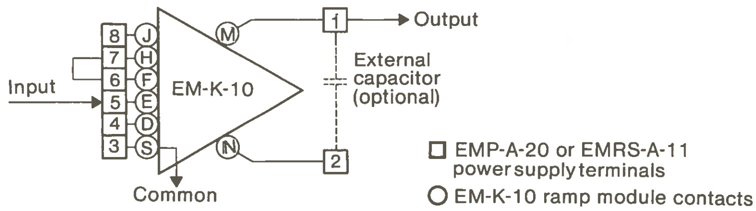



# EM-K-10 application examples

## Single ramp rate circuit

1. Positive and negative input signals are ramped up and down at one rate. Rate is adjustable by ramp rate no. 1 potentiometer.

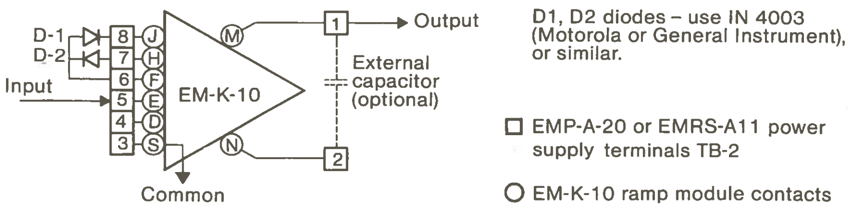
### Circuit 1




## Dual ramp rate circuit with diode steering logic

1. A positive going input signal is ramped up at a rate adjusted by ramp rate no. 1 potentiometer.
2. A negative going input signal is ramped down at rate adjusted by ramp no. 2 potentiometer.

### Circuit 2

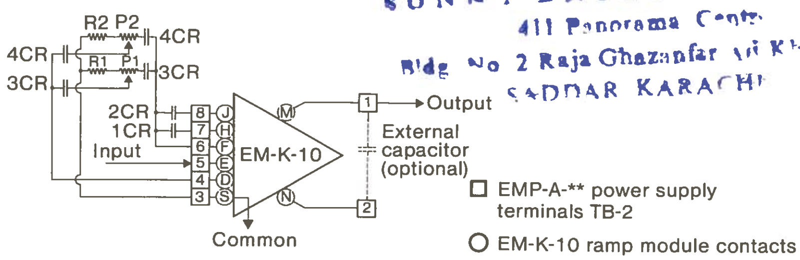



## Internal and external ramp adjustments with relay logic

1. 1CR energized – a positive or negative going input signal is ramped up or down at a rate adjusted by ramp rate No. 1 potentiometer.
2. 2CR energized – a positive or negative going input signal is ramped up or down at a rate adjusted by ramp rate No. 2 potentiometer.
3. 3CR energized – a positive or negative going input signal is ramped up or down at a rate adjusted by potentiometer P1.

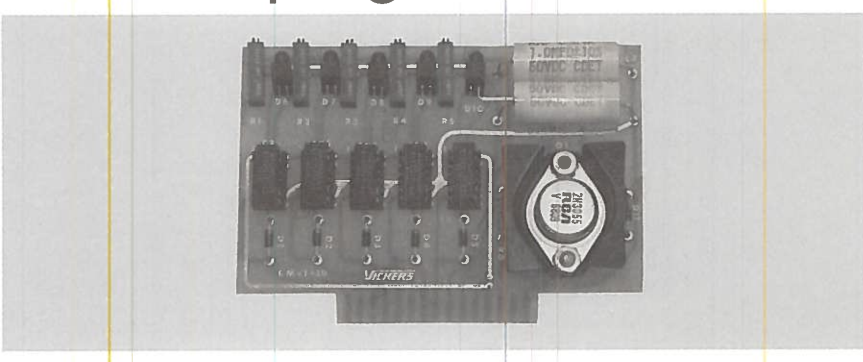
### Circuit 3



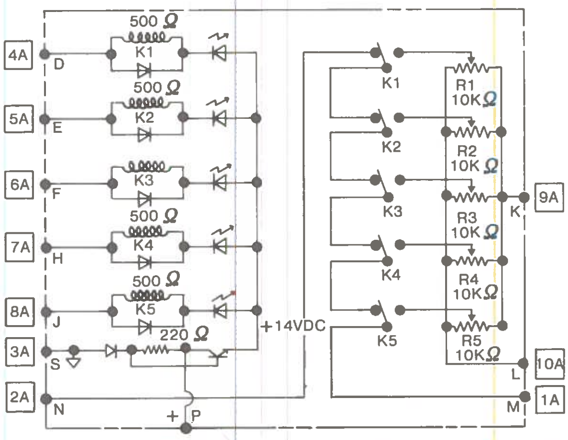



4. 4CR energized – a positive or negative going input signal is ramped up or down at a rate adjusted by potentiometer P2.
5. Any number of ramp rates may be obtained by adding additional resistor or potentiometer combinations.
   P1, P2 potentiometer size, each – 10,000 ohm, 1/2 watt.
   R1, R2 resistor size, each – 470 ohm, 1/2 watt.

# EM-J-10 programmer module



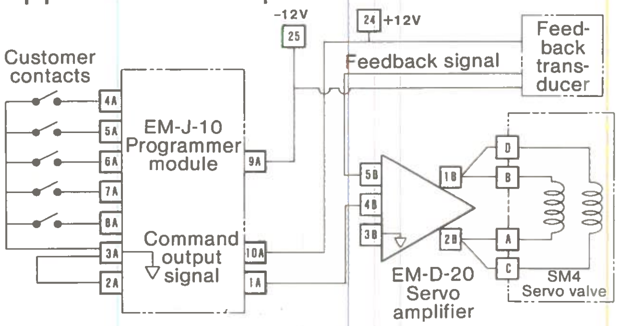
## 1. Circuit and connections




## EM-J-10 Ratings

| | |
|---|---|
| Relays | 12 V, dual inline, reed type |
| Relay coil current | 28 mA |
| Supply voltage | +20 V DC nominal |
| Relay contact maximum rating | 500 mA, 100 V |
| Potentiometer type | 10 k Ohms, 22 turns |
| Potentiometer resistance element | Connected in parallel. |
| Potentiometer wipers | Connected in series. |
| General | |
| Ambient temperature range | 0 to 50°C (32 to 122°F) |
| Installation dimensions | See at right. |
| Mass (weight): | 0,45 kg (1 lb) |
| Application example | See below. |

## EM-J-10 application example




Electrical components required: EM-J-10 Programmer module
EM-D-20 Servo amplifier
EMP-A-20 Power supply plate

## 2. EM-J-10 operating data

### Usage

The programmer module provides up to five preset command signals.

When used with an EM-D-20 servo amplifier, the module provides a means of presetting and selecting a variety of positions, speeds, or forces in closed loop servo systems.

This module must be installed in either a single card EMRS-A-11 or the four card EMP-A-20 power supply unit.

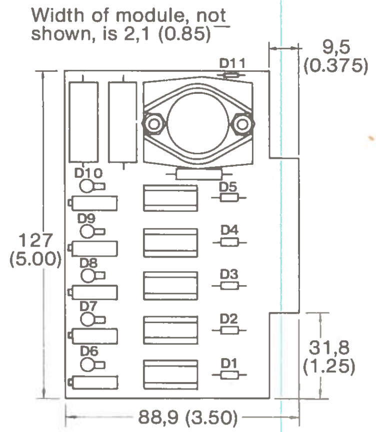
### Design

The programmer module contains five potentiometers, five DC reed relays in dual inline packages, pilot lights for each relay, and an internal power source for the relay.

A relay will be energized when one side of its coil is connected to ground externally by means of a switch or contact closure. The potentiometer associated with this relay is then connected to the output terminal, and sets the output signal level.

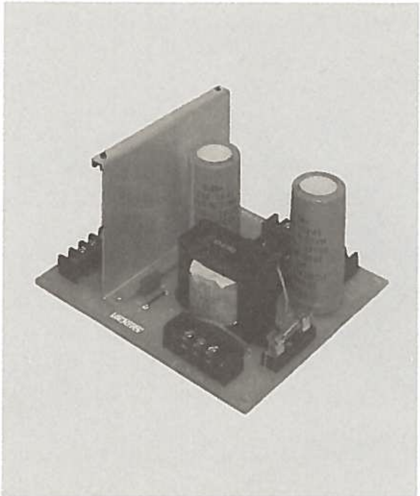
Only one command signal at a time can be delivered by the module, regardless of whether one or more relays are energized simultaneously.

## 3. Installation dimensions; mm (inches)




Servo control application for five preset positions using an SM4 servo valve.

# EMRS-A-11 power supply unit



## 2. EMRS-A-11 operating data

### Usage

The power supply unit is used with Vickers electronic control modules in a single axis electrohydraulic control system.

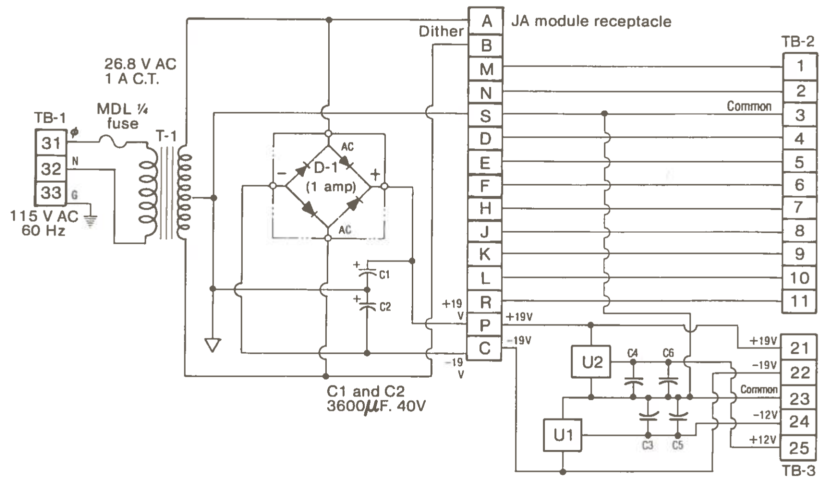
### Design

The power supply unit provides the means for mounting one module, supplying it with the proper excitation voltages, and connecting it to external circuit components through a terminal strip. In addition, a highly regulated ±12V DC power supply circuit is included for excitation of command and feedback circuit components. A separate terminal strip is provided for connections to this circuit.

### EMRS-A-11 ratings

| | |
|---|---|
| Input – TB-1 | |
| Input voltage (no load) | 115 V AC |
| Input frequency | 60 Hz |
| Circuit protection | 3AG 1/4 amp slow blow fuse on input power line |
| Main supply - TB-2 | |
| Output voltage (no-load) | ±19 V DC |
| Output current per leg | 0.6 A DC |
| Maximum ripple | 0.5 V peak to peak |
| Line regulation (10 percent line change) | 10 percent |
| Load regulation (0-0.06A output current change) | 18 percent |

## 1. Circuit and connections

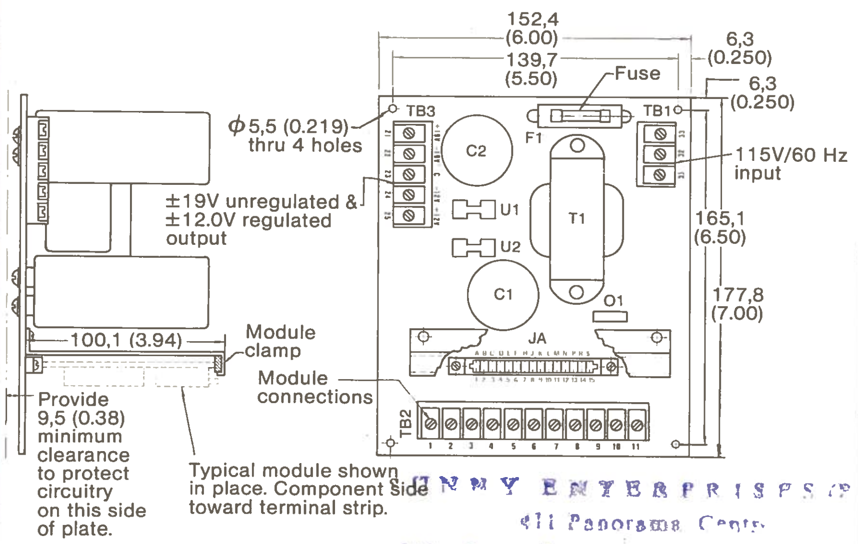



| | |
|---|---|
| Required supply - TB-3 | |
| Output voltage | ±12.0, ±0.12 V DC |
| Output current/leg | 150 mA |
| Short circuit current leg | 1.3 amps |
| Balance | 0.24 V |
| Line regulation (±10 percent line change) | 0.03 V |
| Load regulation (0-0.15A output current) | 0.05 V |
| Temp. regulation | .25 V change over full range |
| Temperature coefficient | 2 mV/°C |
| Warm-up drift | .12 V |

### General

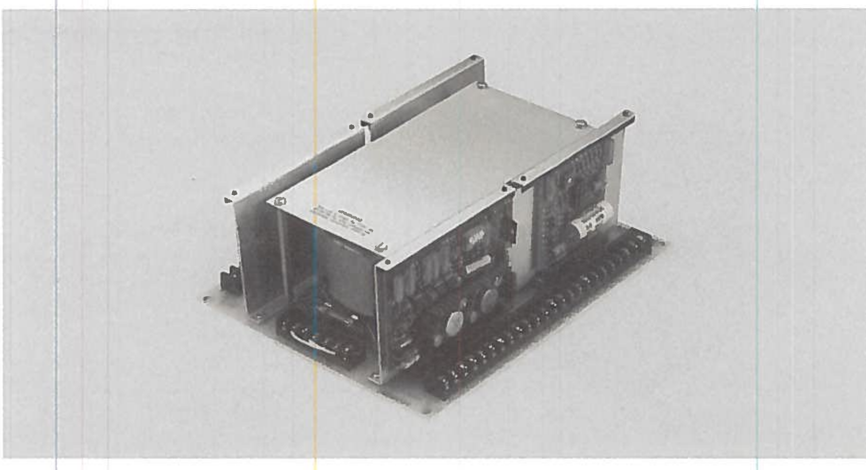
| | |
|---|---|
| Ambient temperature range | 0 to 65°C (32 to 149°F) |
| Installation dimensions | See drawing below. |
| Mass (weight): | 1,14 kg (2.5 lb) |

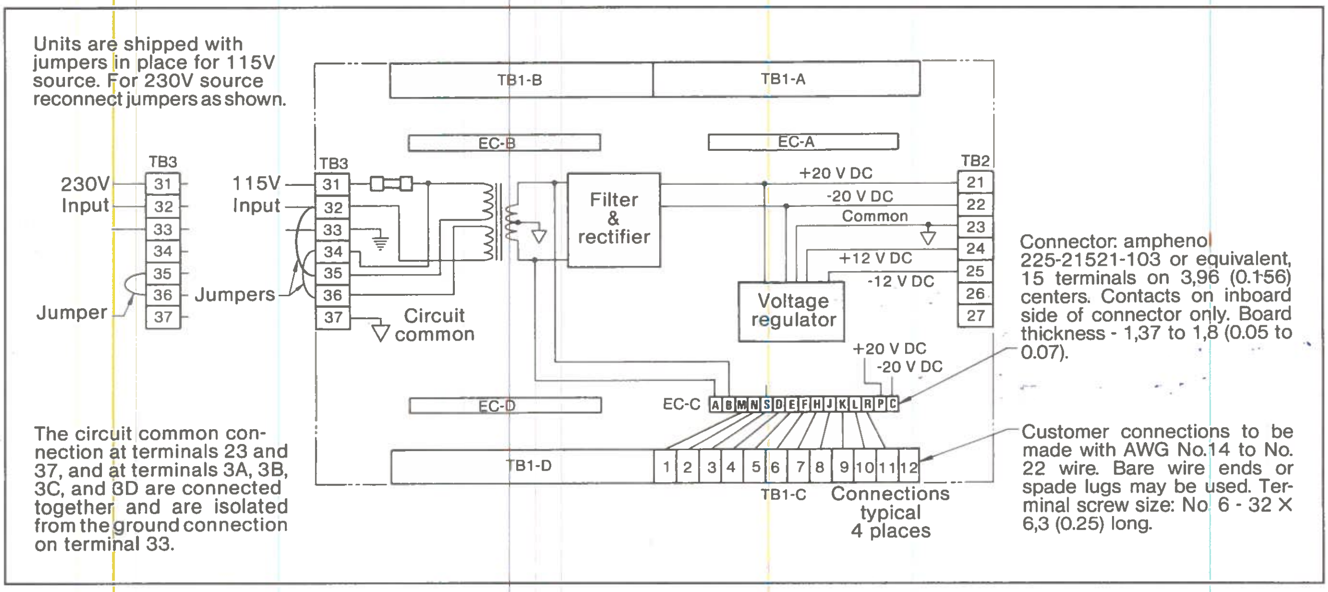
## 3. Installation dimensions; mm (inches)



# EMP-A-20 power supply unit

## 1. Circuit and connections






## 2. EMP-A-20 operating data

### Usage

This power supply unit is used with Vickers electronic modules in servo control systems.

### Design

This power supply unit provides the capability to power up to four EM series modules (two EM-D-20 amplifiers, one EM-K-10 ramp module and one EM-J-10 programmer module) with the proper excitation voltages and connect the modules to external circuit components through a terminal strip.

In addition, a highly regulated ±12V DC power supply circuit is included for excitation of command and feedback circuit components.

### Ratings

| | |
|---|---|
| Input: | |
| Voltage | 115/230 V AC ±10 % |
| Frequencies | 50 or 60 Hz |
| Circuit protection | 1 A time-delay fuse in input power line |
| Ambient temperature range | 0 to 65°C (32 to 149°F) |
| Main output to amplifier: | |
| Voltage, no-load | ±20 V DC |
| Current total | 2,5 A |
| Maximum ripple | 0,6 V RMS |
| Line regulation (10 % line charge) | 12 % |
| Load regulation (0-2,5 A output current change) | 12 % |

## EMP-A-20 operating data

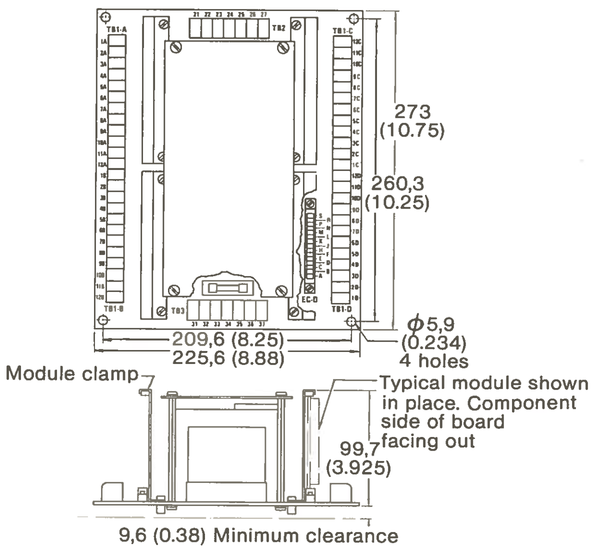
### Ratings

| | |
|---|---|
| Regulated output to command/ feedback circuits (Includes current limiting and thermal shut-down protection) | |
| Voltage | +12 V and −12 V ±0,6 V |
| Current per leg | 200 mA |
| Line regulation (±10 % line change) | 0,05 V |
| Load regulation (0-40 mA current) | 0,03 V |
| Temperature coefficient | 0,002 V/°C (0,001 V/°F |
| Drift after 30 minutes | 0,03 V |

### General

| | |
|---|---|
| Installation dimensions | See below. |
| Mass (weight) without amplifiers | 4,1 kg (9 lb) |

### 3. Installation dimensions; mm (inches)



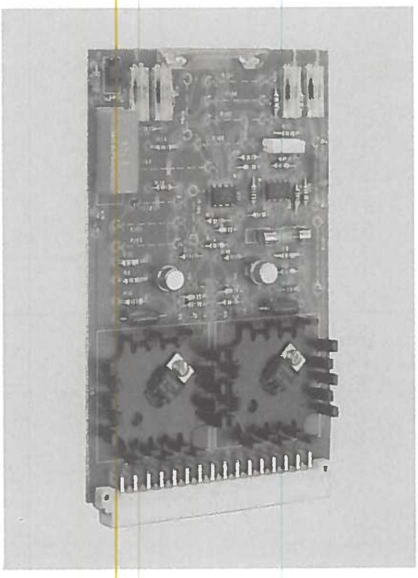



# EEA Servo electronics – Eurocard format

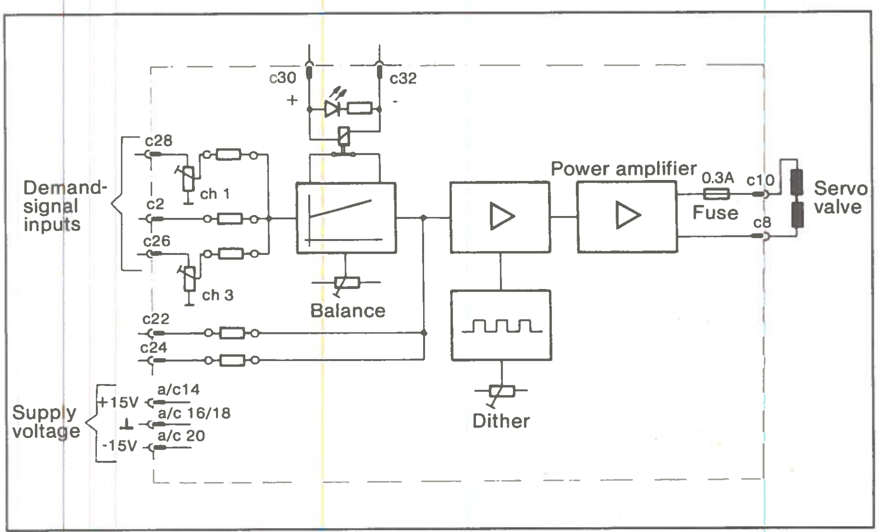
| Basic model | Product summary | Part number |
|---|---|---|
| EEA-PAM-101-A-10 | Servo amplifier card with PI control and reset relay.<br>Power output stage 300 mA maximum into a 50 Ohm load. | 636673 |
| EEA-PAM-104-A-10 | Servo amplifier card with current control<br>Power output stage to 300 mA maximum into a 50 Ohm load. | 636672 |
| EEA-PSU-106-A-10<br>EEA-PSU-106-B-10<br>EEA-PSU-106-C-10<br>EEA-PSU-106-D-10<br>EEA-PSU-106-E-10 | Power supply card in Eurocard format.<br>Input: ±18 V AC<br>Output: ±5 to 24 V DC | 636677<br>636675<br>636676<br>636678<br>636679 |
| EEA-Accessories | Cardholders<br>Female electrical connector<br>Potentiometer | 507739<br>508178<br>714127 |

# EEA servo amplifier card with PI control

Model
EEA-PAM-101-A-10



## 1. Circuit and connections




## 2. EEA-PAM-101-A-10 operating data

| | |
|---|---|
| **Usage** | A driving amplifier in Eurocard format for Vickers servo valves. |
| **Design** | The amplifier circuit incorporates a PI controller with reset relay for the integral function.<br>An LED indicates when the relay is energized.<br>The amplitude of the dither signal is adjustable.<br>Soldered connection points allow free choice of controller circuit configuration. |

### Ratings

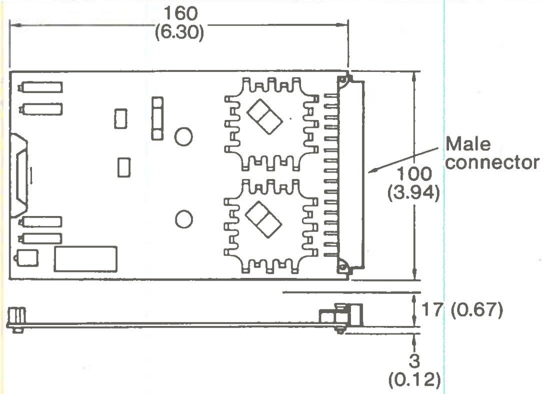
| | |
|---|---|
| Supply voltage | ±15 V DC (regulated) |
| Current consumption | 350 mA max. |
| Power consumption | 5,5W max. |
| Output current | 300 mA max. |
| Load resistance | 50 max. |
| Reset relay incl. LED | 24 V DC, 30mA |
| Dither frequency | 100 Hz (square wave) |

### General

| | |
|---|---|
| Ambient temperature range | 0 to 50°C (32 to 122 °F) |
| Mounting position | Unrestricted |
| Connections | DIN 41612, type D32 Male connector |
| Installation dimensions | See below. |

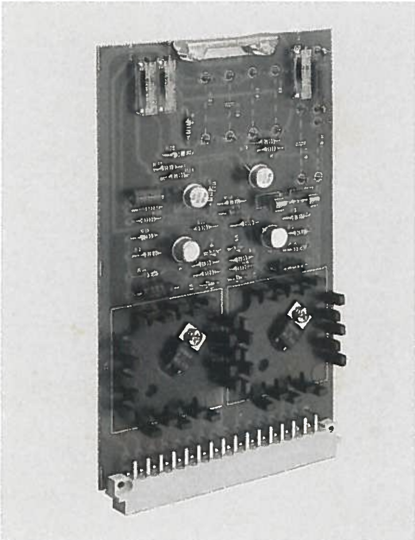
## 3. EEA-PAM-101-A-10 servo amplifier installation dimensions; mm (inches)

The function of each adjustment potentiometer is printed in the appropriate position on each Eurocard.

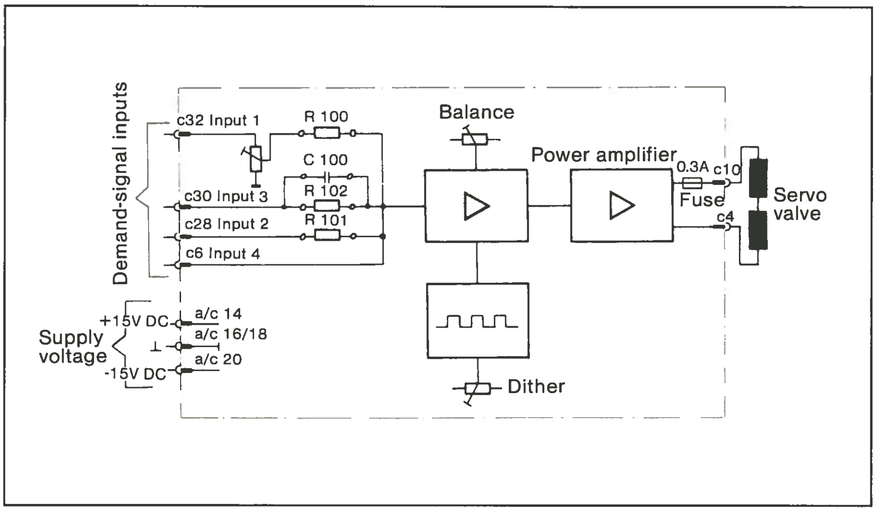


# EEA servo amplifier card with current control

Model
EEA-PAM-104-A-10



## 1. Circuit and connections




## 2. EEA-PAM-104-A-10 operating data

| | |
|---|---|
| **Usage** | A driving amplifier in Eurocard format for Vickers servo valves. |
| **Design** | A current proportional to the applied demand signal is output to the valve and is maintained constant irrespective of temperature changes in the torque motor coil. Soldered connection points allow free choice of amplifier circuit configuration. The amplifier of the dither signal is adjustable. Input 1 (c32) is provided with an on-card potentiometer for adjusting the input signal. The amplitude of the dither signal is adjustable. The "no signal" solenoid current can be adjusted and set by means of the "balance" potentiometer. |

### Ratings

| | |
|---|---|
| Supply voltage | ±15 V DC (regulated) |
| Current consumption | 350 mA max. |
| Power consumption | 5,5 W max. |
| Output current | 300 mA max. |
| Load resistance | 50 max. |
| Dither frequency | 100 Hz (square wave) |

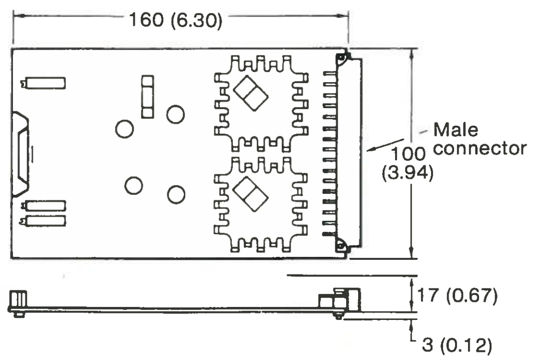


### General

| | |
|---|---|
| Ambient temperature range | 0 to 50°C (32 to 122 °F) |
| Mounting position | Unrestricted |
| Connections | DIN 41612, type D32, male connector |
| Installation dimensions | See below. |

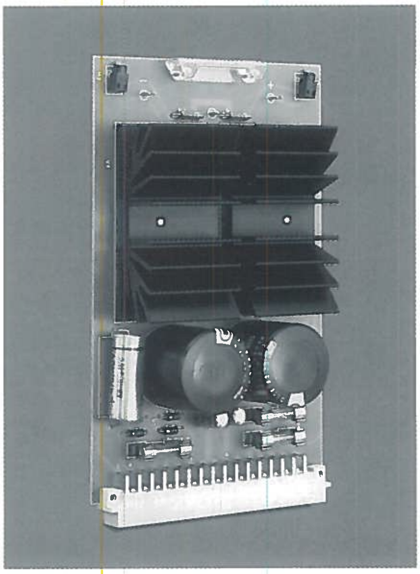
## 3. EEA-PAM-104-A-10 servo amplifier installation dimensions; mm (inches)

The function of each adjustment potentiometer is printed in the appropriate position on each Eurocard.

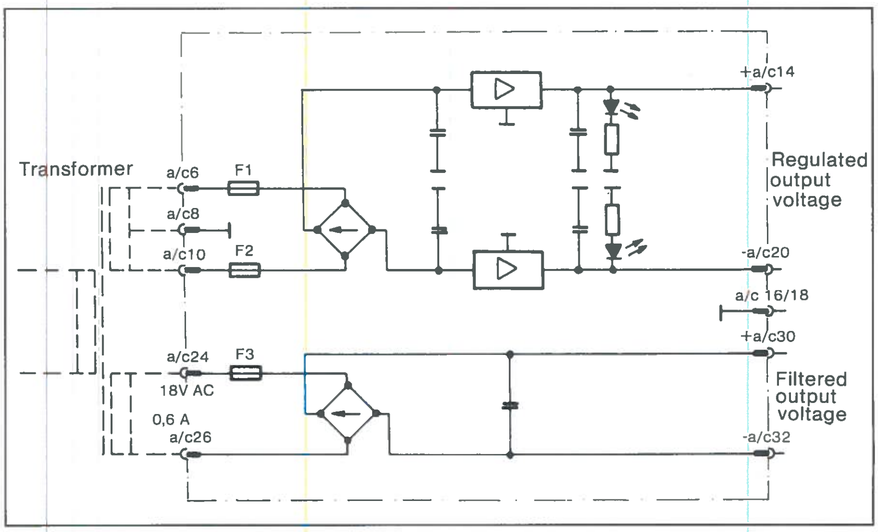


# EEA power supply card in Eurocard format

Model
EEA-PSU-106-*-10



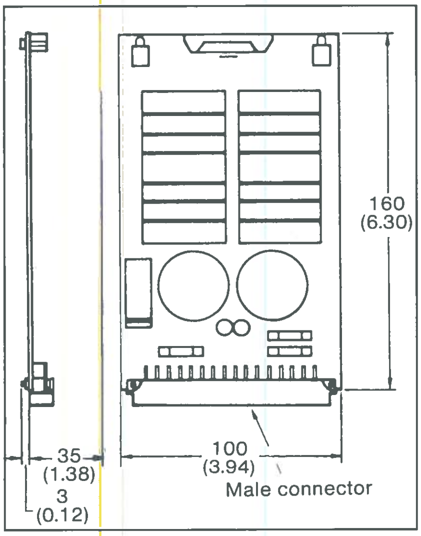
## 1. Circuit and connections




## 2. EEA-PSU-106-*-10 operating data

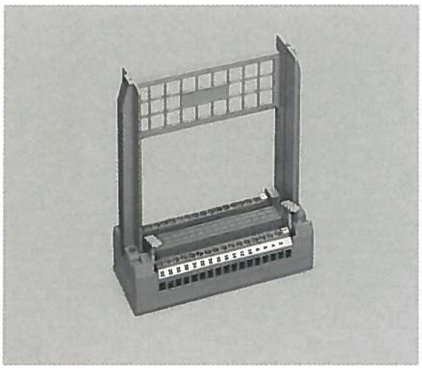
| | |
|---|---|
| **Usage** | This power supply board is designed to provide a supply voltage for those Eurocards which do not generate their own reference voltage, i.e. EEA-PAM-101/104 |
| **Design** | Regulated voltages from ±5 to ±24V DC are available dependent on model type. LED indicates the operating condition of the positive and negative voltage regulators. A second independent circuit generates a filtered DC voltage for auxiliary functions, such as the switching of relays. |
| **Ratings** | |
| Supply voltage, regulated | 3 V AC above the regulated output voltage |
| Supply current | 1,0A maximum |
| Output voltage, regulated: | |
| EEA-PSU-106-A-10 | ±5 V DC |
| EEA-PSU-106-B-10 | ±12 V DC |
| EEA-PSU-106-C-10 | ±15 V DC |
| EEA-PSU-106-D-10 | ±18 V DC |
| EEA-PSU-106-E-10 | ±24 V DC |
| Output current | 1,0 A max. |
| Supply voltage, filtered | 18V AC |
| Supply current | 0,6 A |
| Output voltage, filtered | 24V DC |
| Output current | 0,6A max. |
| **General** | |
| Ambient temperature range | 0 to 50°C (32 to 122°F) |
| Mounting position | Cooling fins must be in a vertical position. |
| Connections | DIN 41612, type D32, male connector |
| Installation dimensions | See at left. |

## 3. EEA-PSU-106-*-10 installation dimensions; mm (inches)



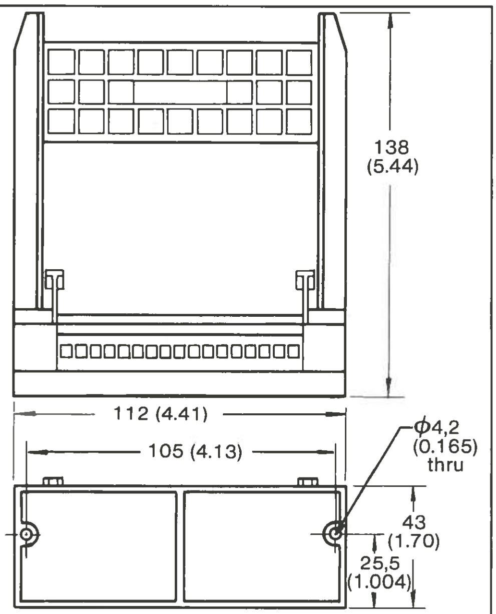
# EEA accessory products

## Cardholder complying with DIN 41612



For EEA cards with female connector type D32 (Part no. 507739)
These cardholders can be permanently mounted. Screw terminals ensure quick and secure wiring. The electronic cards clip into their respective cardholers, preventing them unintentionally working loose.

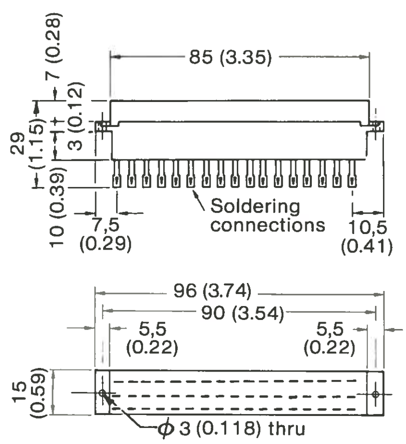
Installation dimensions; mm (inches)




## Female connector complying with DIN 41612

Type D32 for certain EEA cards (Part no. 508178)
These female connectors, fitted with connection pins for soldering, are used when the electronic cards are housed in a 19 inch rack.

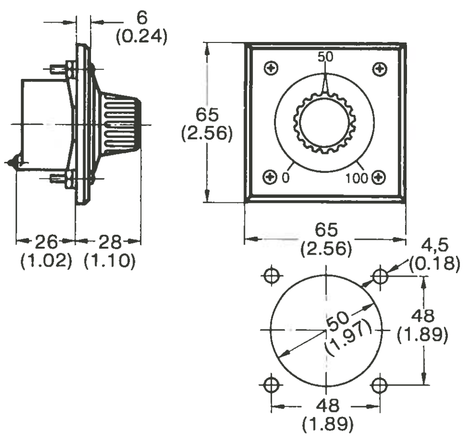
Installation dimensions; mm (inches)




## Demand-signal potentiometer

(Part no. 714127)
R = 5k Ohm; dial scale 0 . . . 1000 %
This potentiometer with built-in dial should be used to externally set the demand signal for the electronic cards.

Installation dimensions; mm (inches)



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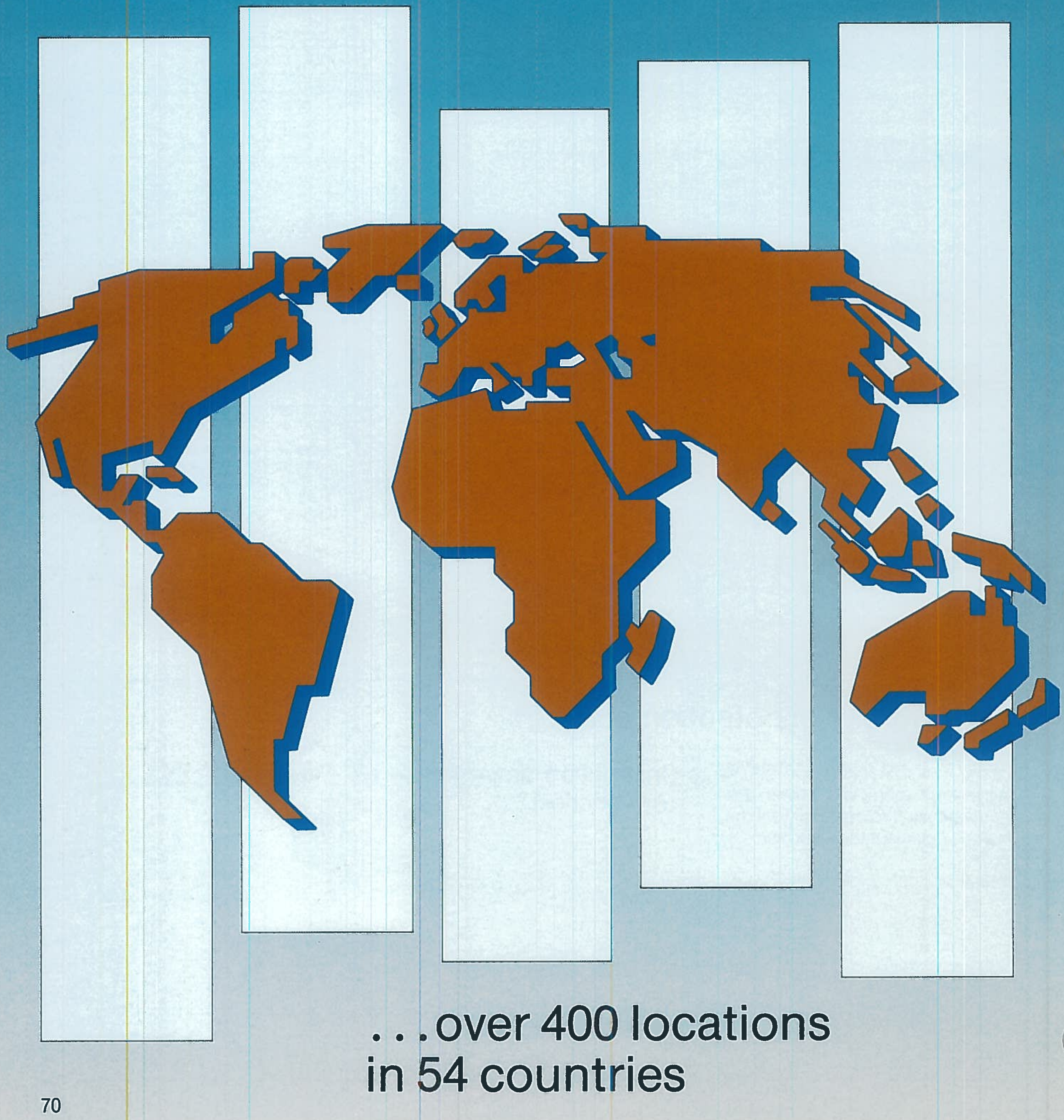

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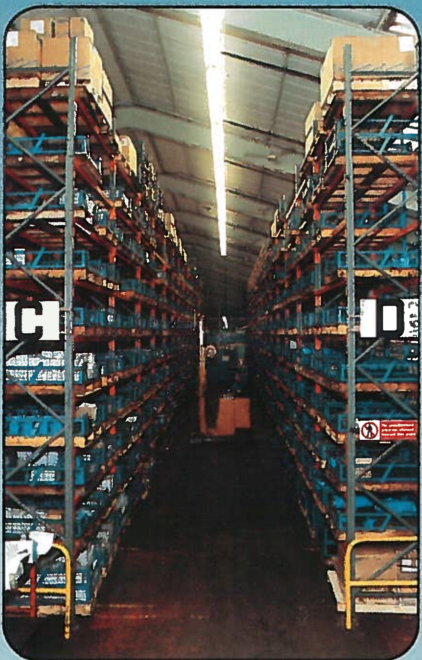


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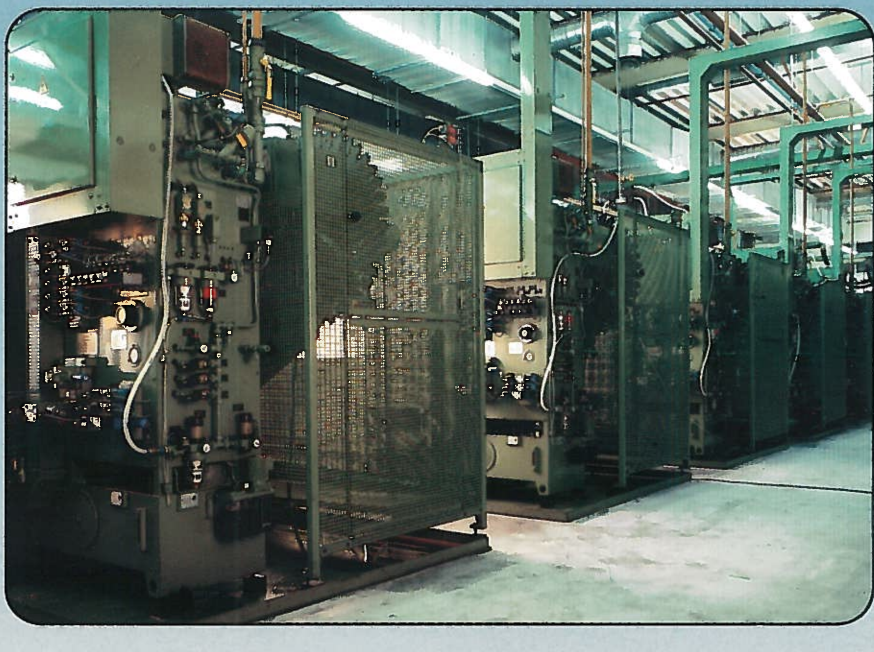

# New EHT1 portable electrohydraulic trainer

## ...easy to understand advanced motion control

The EHT 1 trainer includes basic hydraulic components and one to five modular electronic controls, depending on your option requirements. This allows trainer modules to be added whenever you like.

### Circuits demonstrated

1. Proportional open loop control
2. Proportional closed loop control
3. Closed loop spool positioning
4. Servo position control
5. Servo velocity control
6. Digital closed loop control

### Display panel components

- KDG4V-3 electrohydraulic proportional solenoid valve
- SM4-20 analog servo valve
- SM4-20 DCL digital and closed loop servo valve
- MFB5 piston motor with special servo mounting
- KFDG4V-3 electrohydraulic proportional solenoid valve with position feedback
- XLA closed loop electrohydraulic cylinder
- Closed loop feedback transducer
- 18″ standard hydraulic cylinder

### Electronic modules

1. Command module - allows you to apply inputs to other amplifier modules, and simulate machine functions through multi-axis control.
2. Servo training module - lets you demonstrate how high performance servos achieve precise, reliable electrohydraulic motion control.
3. Open loop proportional controller - demonstrates directional control capability from a single valve source. Students see how system design can be simplified from previously complex solenoid valve set-ups.
4. Closed loop proportional control module - shows how proportional valves increase flexibility, simplify machine design, and improve productivity through infinitely variable control of actuator speeds.
5. Digital and closed loop training module - allows students to get "hands on" experience by performing multiple axis functions and changing system parameters.

### Structured experiments

All experiments are designed to allow a student to perform actual system start-ups, functions and tests. Experiments start with a basic amplifier, valve and actuator. Thereafter, each training session builds on the other, so that each student has step-by-step instructions that are easy to teach and easy to learn. The experiments advance the student toward a complete overview of electrohydraulic motion and control... right up through the latest advancements in electrohydraulic technology.

### Hydraulic power unit

This unit consists of a pump, reservoir, pressure controls and pressure line filtration...all enclosed in a metal cabinet to keep sound levels down. Storage area for quick-disconnect hydraulic hoses and jumper cables is provided, along with a pullout work tray.

- 2,3 kW (3 hp) electric motor
- 76 l/min (20 US gal.) reservoir
- 70 bar (1000 psi) relief valve
- 2 – 5 micron pressure line filter
- Oil level sight gauge
- Air breather and filler cap
- Remote pressure control valve

### Comprehensive documentation

- Instructor's guide and tests
- Experiments workbook
- Maintenance manual
- Two-day instructor training session

**Please ask for complete information package 465.**